Connecticut Department of Energy and Environmental Protection

Connecticut Department of
ENERGY &
ENVIRONMENTAL
PROTECTION

May 25-29, 2016 Ozone Exceptional Event Analysis for Connecticut

Michael Geigert

Connecticut Department of Energy and Environmental Protection

Fort McMurray Wildfire

On May 1, 2016, a wildfire began southwest of Fort McMurray, Alberta, Canada. On May 3, it swept through the community, destroying approximately 2,400 homes and buildings and forcing the largest wildfire evacuation in Albertan history. The fire spread across approximately 590,000 hectares (1,500,000 acres) before it was declared to be under control on July 5, 2016.

Available Tools for Analysis

- [Satellite animation with AOD estimations](#);
- Analyzed plume coverage by [NESDIS](#) ;
- [Calipso satellite](#) aerosol analysis;
- [Airnowtech Navigator](#) trajectory analysis;
- [Hysplit](#) trajectory analysis;
- [NOAA Model Forecasts](#);
- [NWS archive surface analysis](#);
- [Airnow AQI maps](#);
- CTDEEP PM2.5, BC, and Ceilometer data.

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Exceptional Event Guidance

✔ **Maps and tables of the wildfire event information including location, size, and extent.**

✔ **Characteristics and description of the monitor with the request for data exclusion**.

✔ **A brief explanation and identification of the cause and point of origin for the event.**

✔ **Examples of media coverage of the event, including special weather statements, advisories, and news reports.**

❓ **Smoke forecasts based on meteorology and burn conditions;**

✔ **Description of meteorological data from or near the affected monitor and how this relates to the transport of the wildfire emissions.**

✔ **Description of the route of the wildfire emissions to the influenced monitor, including meteorological information regarding the transport of wildfire emissions to the monitor.**

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Exceptional Event Guidance

✓ **Non-event O3 formation characteristics of the area normally influencing the monitor (*i.e.*, the non-event conceptual model).**

✓ **Discussion of the differences observed between the non-event conceptual model and event related conditions causing high O3 concentrations at a particular location.**

✓ **A summary of spatial and temporal O3 patterns on the day of interest, and days before and after the event.**

✓ **Description of the regulatory determination anticipated to be influenced by the exceptional event, including a table of the monitor data requested for exclusion**

✓ **NAAQS attainment and classification information, including O3 State Implementation Plan (SIP) status.**

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Weight of Evidence

We intend to show :

- **Effects of the exceptional event on the regulatory determination on the Westport monitor;**

- **The route of the wildfire emissions to the influenced monitors, including meteorological information regarding the transport of wildfire emissions to the monitor;**

- **Satellite imagery and smoke plume analysis that shows the Fort McMurray plume settling over the Great Lakes area producing high concentrations of ozone that subsequently gets transported to Connecticut;**

- **Why, at the onset of the event, meteorological conditions were not conducive for producing the high levels of ozone that were observed at our monitors;**

- **That the NOAA operational ozone model, which did not incorporate real time wildfire emissions into the inventory, was under predicting ozone levels at the onset by at least 10 ppb;**

- **Monitoring data at our sites was showing black carbon, PM2.5 and other parameters that concur with the presence of a smoke plume during the ozone event.**

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Connecticut 8-hour Ozone 2016 Design Values (Preliminary)

Elevation: 513 m (1683 ft)

Legend:
- ⬤ ≤ 70 ppb 8-hr Average
- ⬤ ≥ 71 ppb 8-hr Average
- ⬤ ≥ 85 ppb 8-hr Average

Stafford 73

Cornwall 73

Abington 68

East Hartford 75

Middletown 79

Danbury 78

New Haven 76

Madison 76

Groton Fort Griswold 72

Stratford 81

Westport 85

Greenwich 82

- ⬛ NY-NJ-CT Non-attainment Area
- ⬜ Greater CT Non-attainment Area
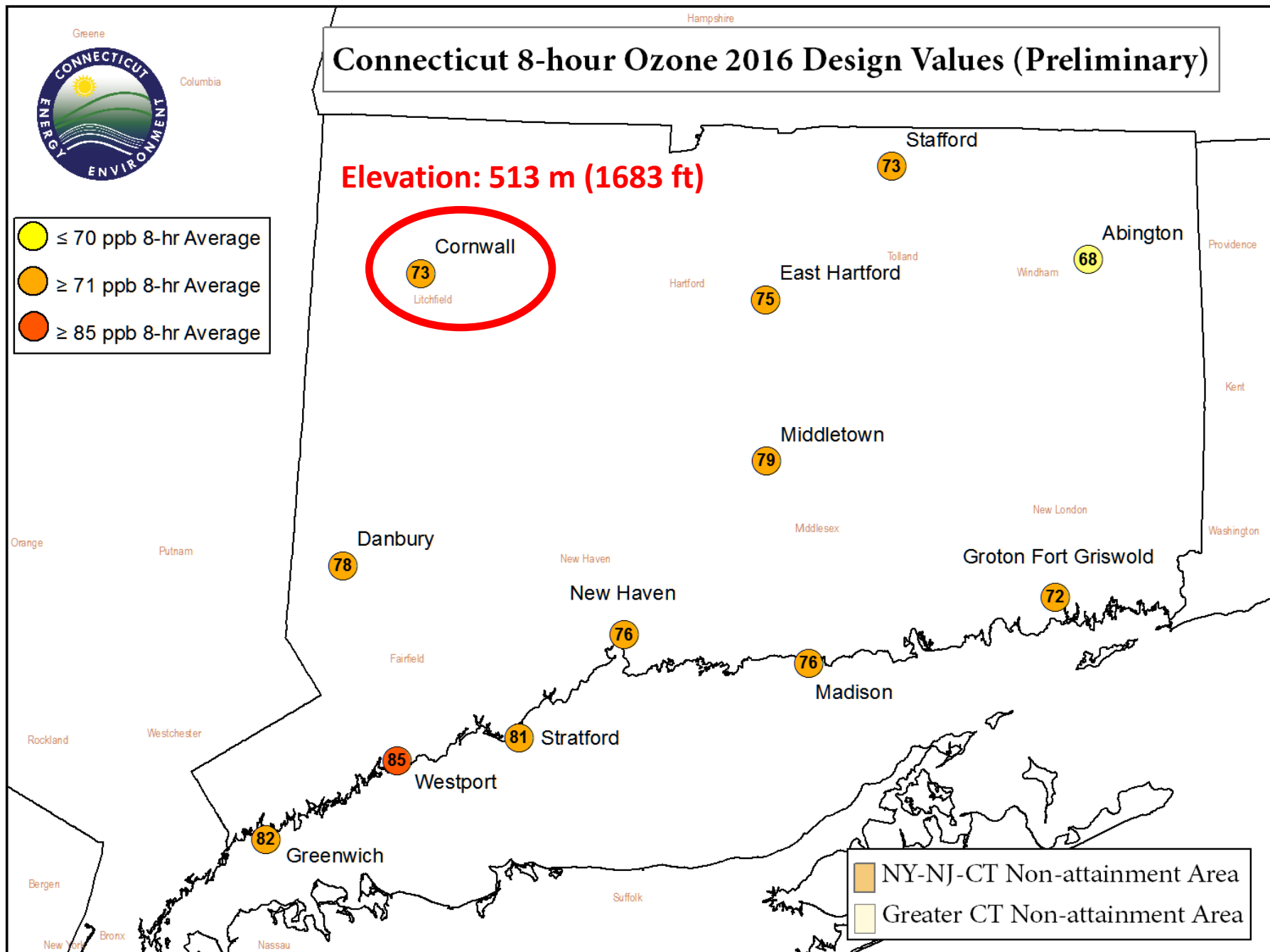
Attainment Status Affected

- May 25-26 had the most impact on current design values

May 25-29, 2016 Ozone					
	5/25/2016	5/26/2016	5/27/2016	5/28/2016	5/29/2016
Greenwich/O3	89	91	63	82	59
Danbury/O3	82	99	81	81	73
Stratford/O3	89	76	59	70	47
Westport/O3	87	90	61	81	58
East Hartford/O3	75	93	70	81	66
Middletown/O3	80	91	67	79	61
Stafford/O3	74	82	70	73	56
Cornwall/O3	81	91	78	65	69
New Haven - Criscuolo Park/O3	63	84	65	73	54
Groton Fort Griswold/O3	87	80	54	60	51
Abington/O3	76	83	68	67	52
Madison/O3	89	86	56	63	48

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Attainment Status Affected

- Westport 2016 DV would drop to 83 ppb!

2016, Excluding May 25 & 26					2015	2014	2016
Site Name	1st Max	2nd Max	3rd Max	4th Max	4th Max	4th Max	DV
Greenwich/O3	87	85	82	81	84	78	81
Danbury/O3	87	81	81	80	79	74	77
Stratford/O3	96	84	83	82	86	74	80
Westport/O3	97	87	87	81	87	81	83
East Hartford/O3	81	76	72	72	75	77	74
Middletown/O3	100	84	80	79	78	80	79
Stafford/O3	73	72	71	70	72	77	73
Cornwall/O3	79	78	75	74	76	66	72
New Haven/O3	91	80	75	75	81	72	76
Groton Fort Griswold/O3	82	75	75	75	77	65	72
Abington/O3	74	68	67	67	70	67	68
Madison/O3	82	80	78	78	81	69	76

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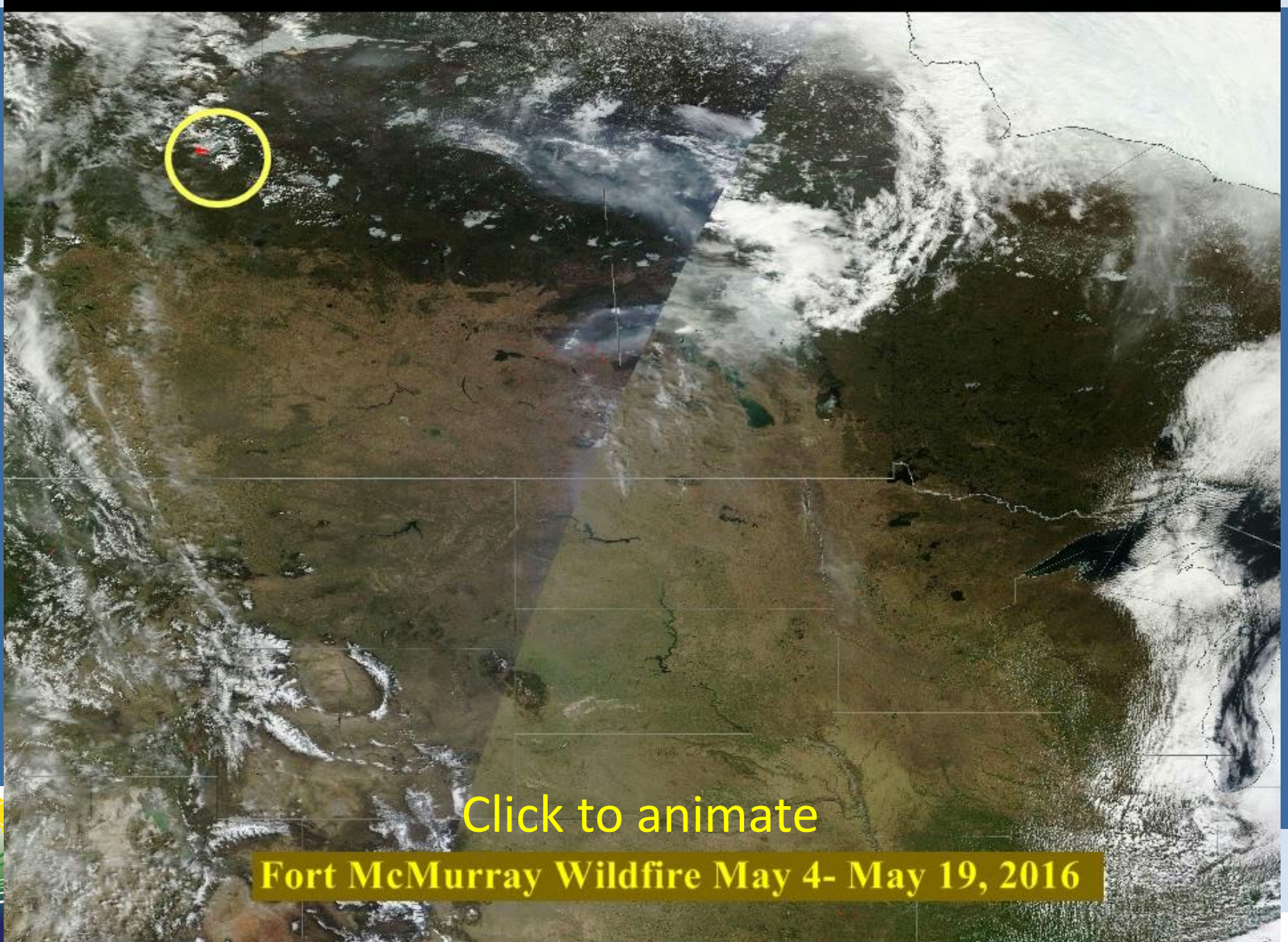
Click to animate

Fort McMurray Wildfire May 4- May 19, 2016

May 20-28 AOD Satellite Animation

AOD May 20-28, 2016
May 20

Orange and red AOD signify
Higher aerosol concentrations in
Total vertical column (not surface)
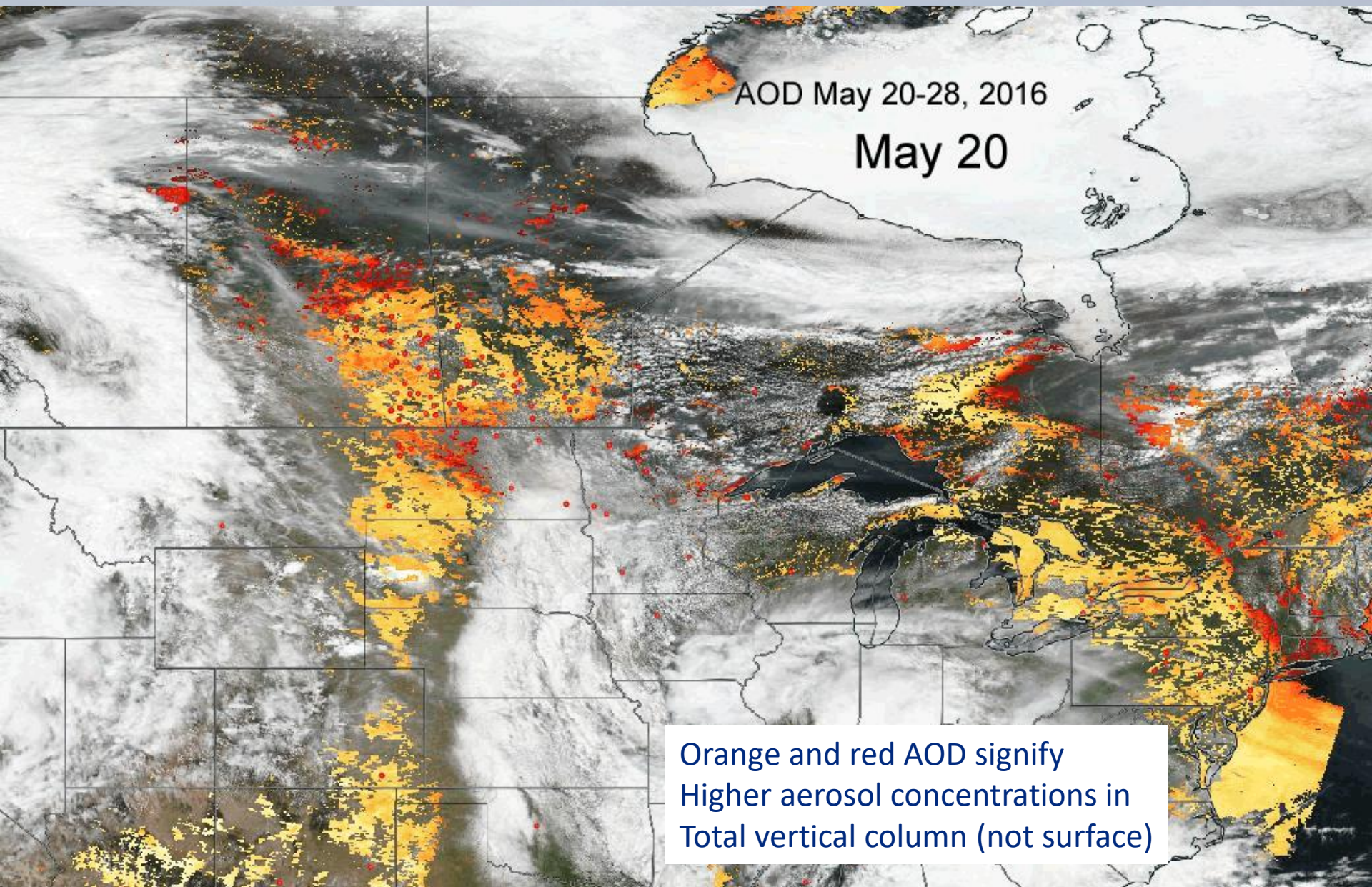
# Smoke Plume Animation from May 18th- May 25th
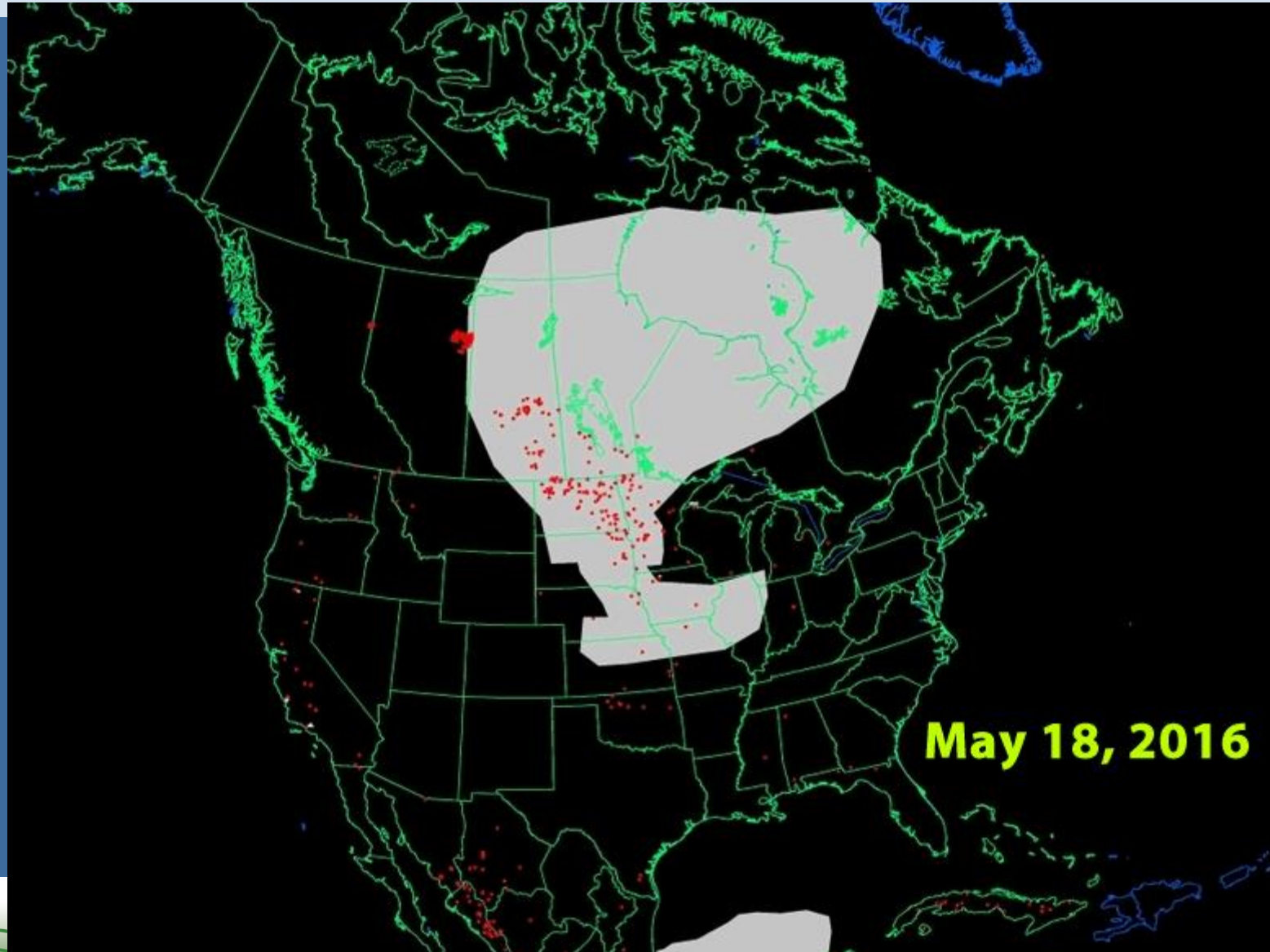
May 18, 2016

Plume and Aerosols on May 18, 2016

- On May 18, 2016, the plume began dispersing towards the upper Midwest and Great Lakes, where it was trapped beneath a dome of high pressure

18 May 2016
0   Aerosol Index   10
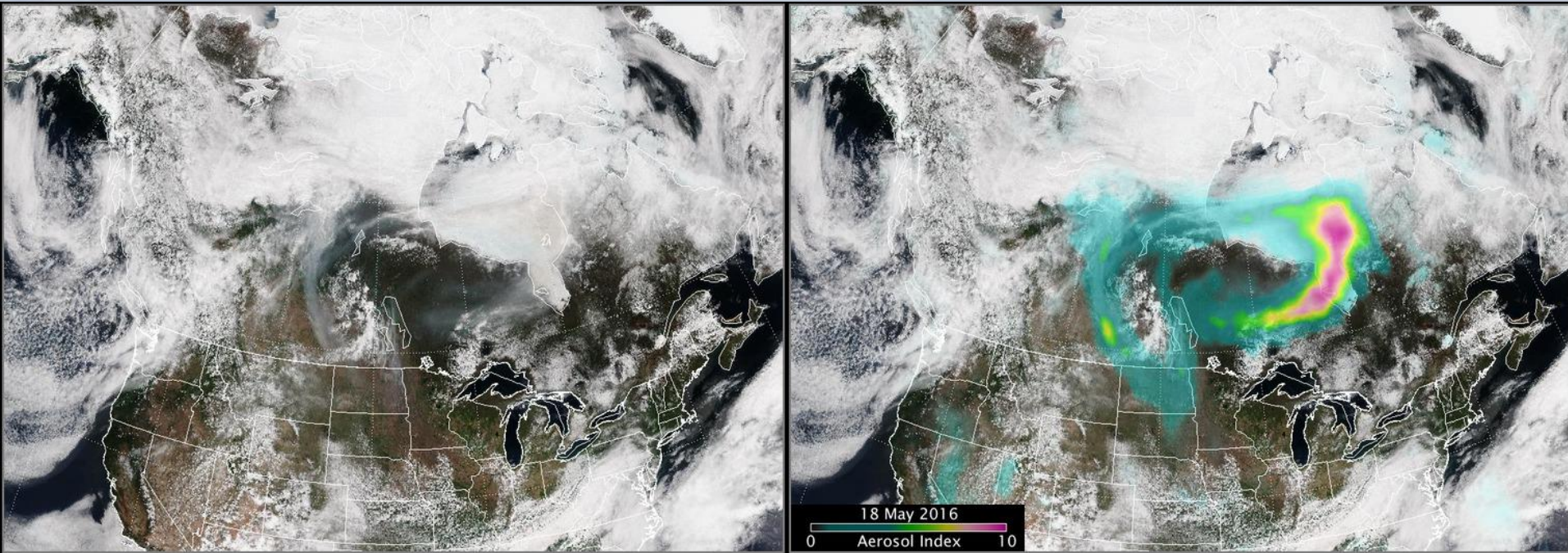
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Plume and Aerosols on May 19, 2016

- On May 19, 2016, the plume was over the upper Midwest pushing toward New England.

19 May 2016
0   Aerosol Index   10

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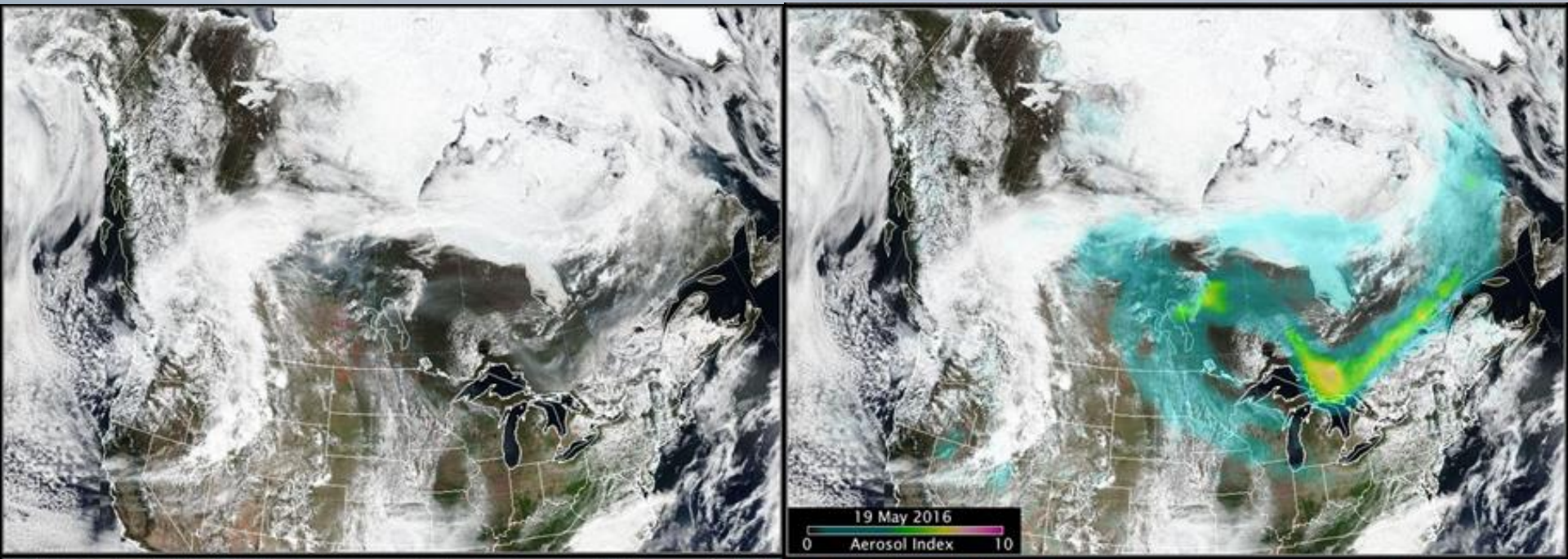
Plume and Aerosols on May 20, 2016

- On May 20, 2016, a lobe of the plume crosses New England, but stays aloft.

20 May 2016
0.0   Aerosol Index   4.0

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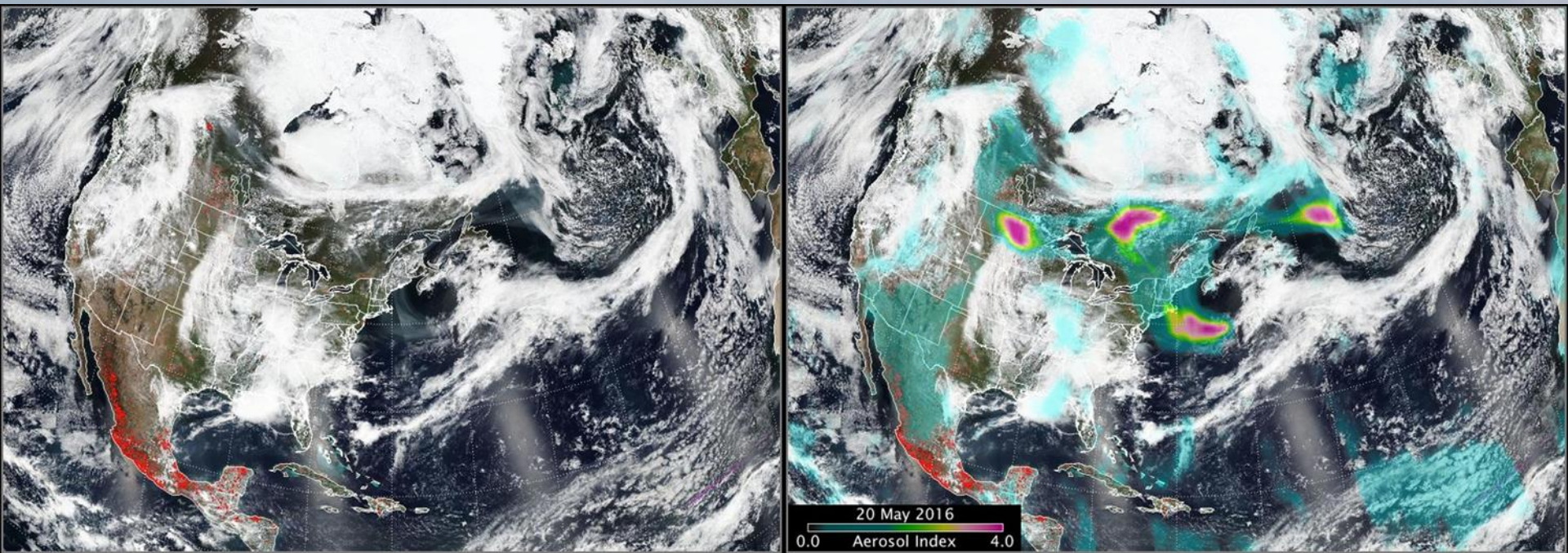
Smoke Plume Appears over CT on May 20th

- Skies became 'hazy' for several hours, but PM2.5 remains 'GOOD'

1045 UTC 20 May 2016 Visible Image (c)2016 UCAR http://www.rap.ucar.edu/weather/satellite/

May 20, 2016 PM2.5 Concentrations

Hartford-Huntle
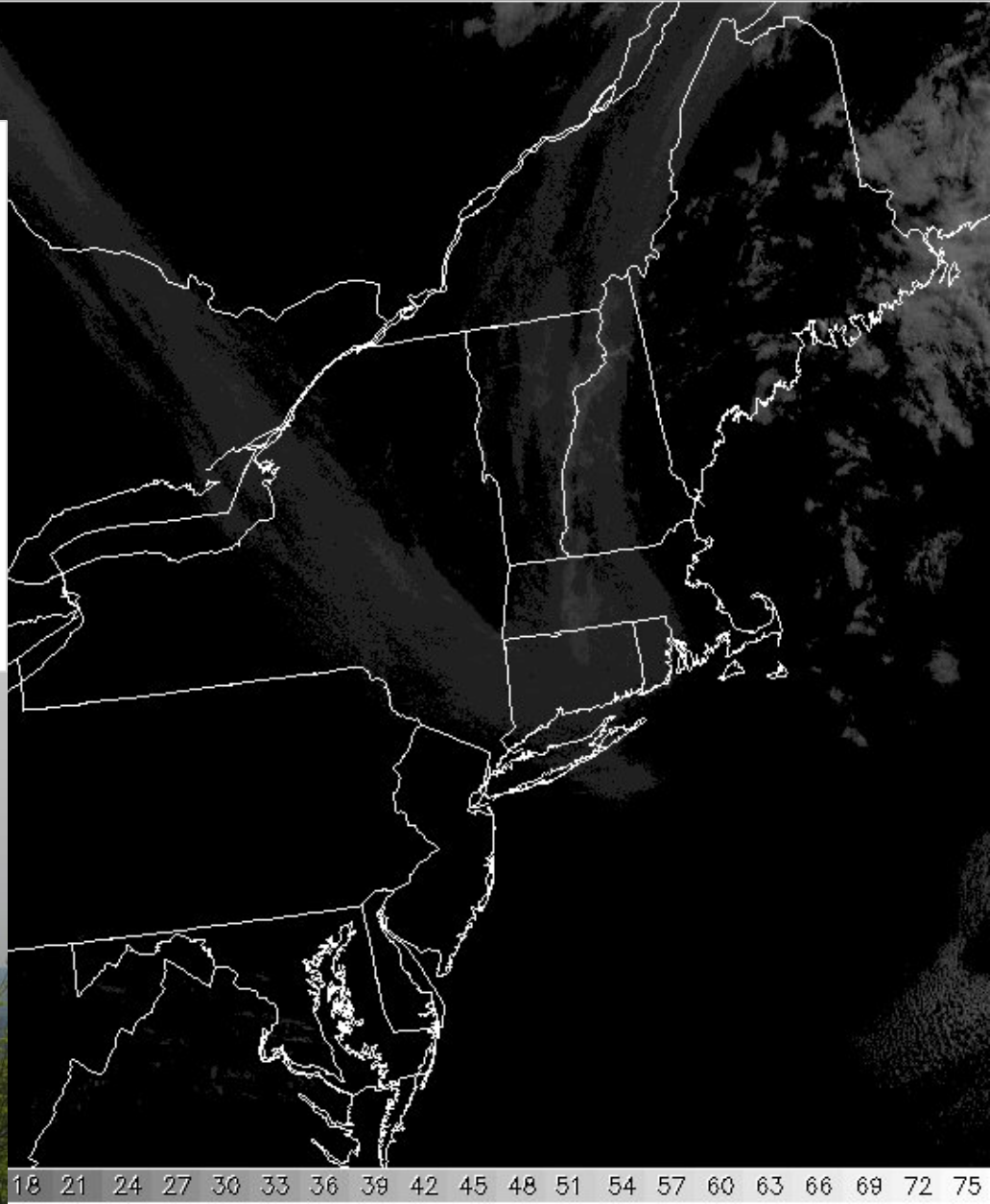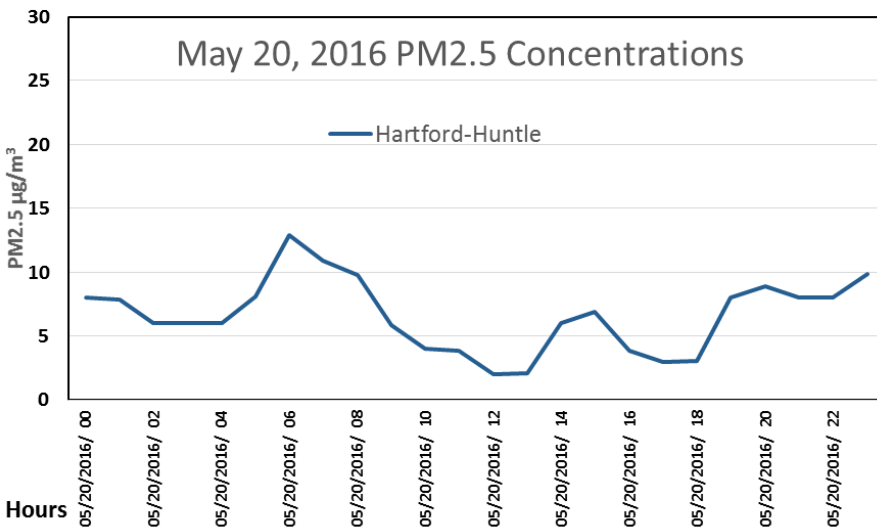
Surface Animation May 18-24, 2016
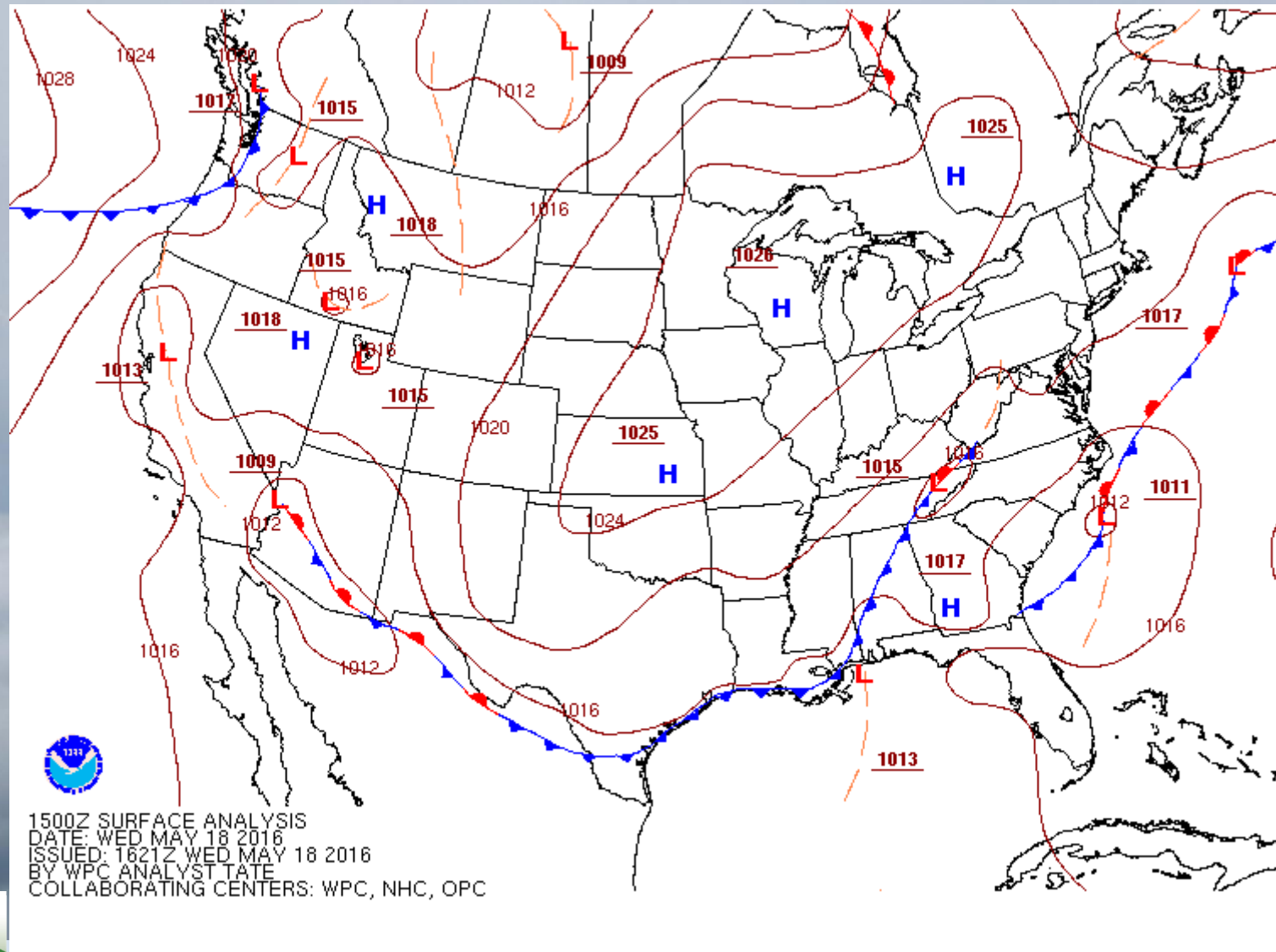
- On May 18, 2016, the plume began dispersing towards the upper Midwest and Great Lakes, where it was trapped beneath a dome of high pressure

Calipso LIDAR 5/22/16
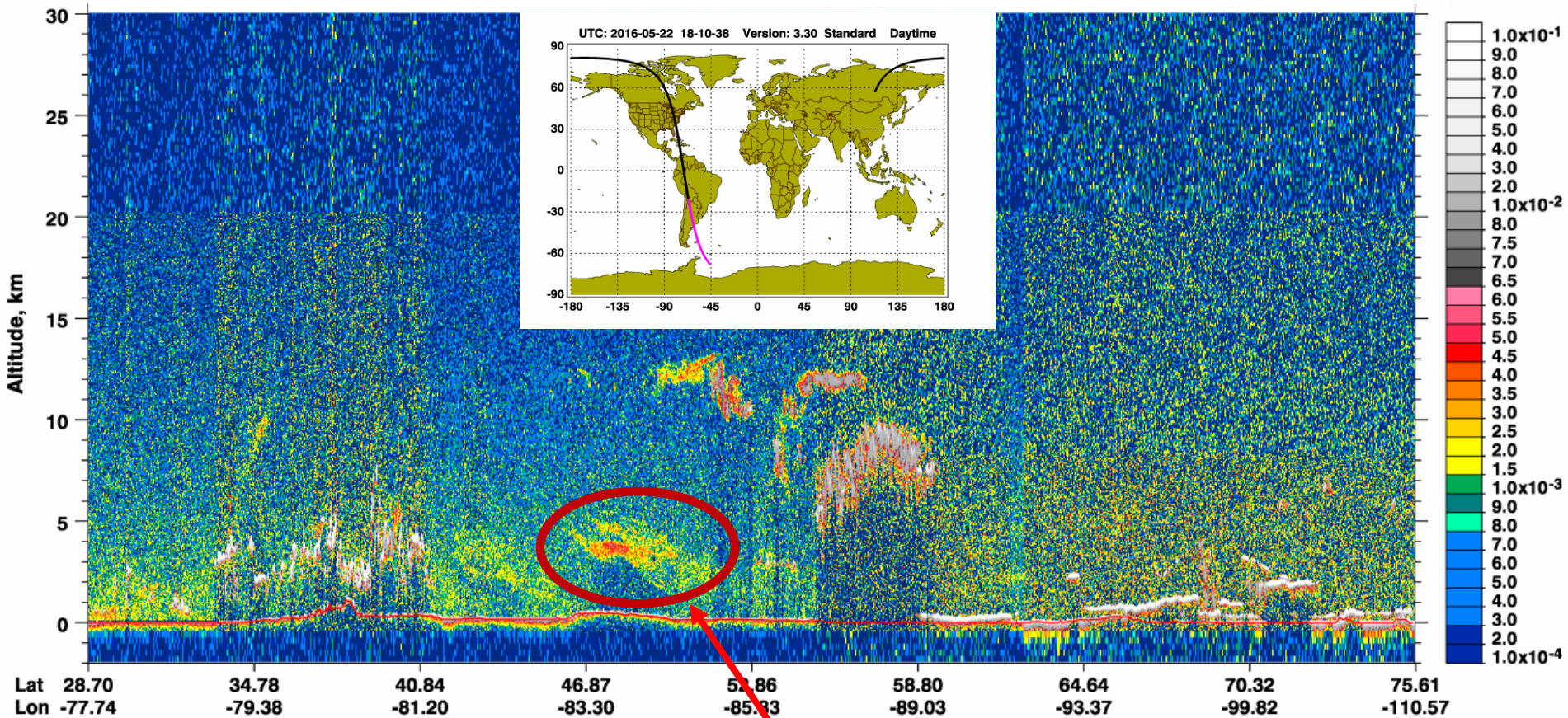
Connecticut Department of Energy and Environmental Protection

Calipso LIDAR 5/23/16
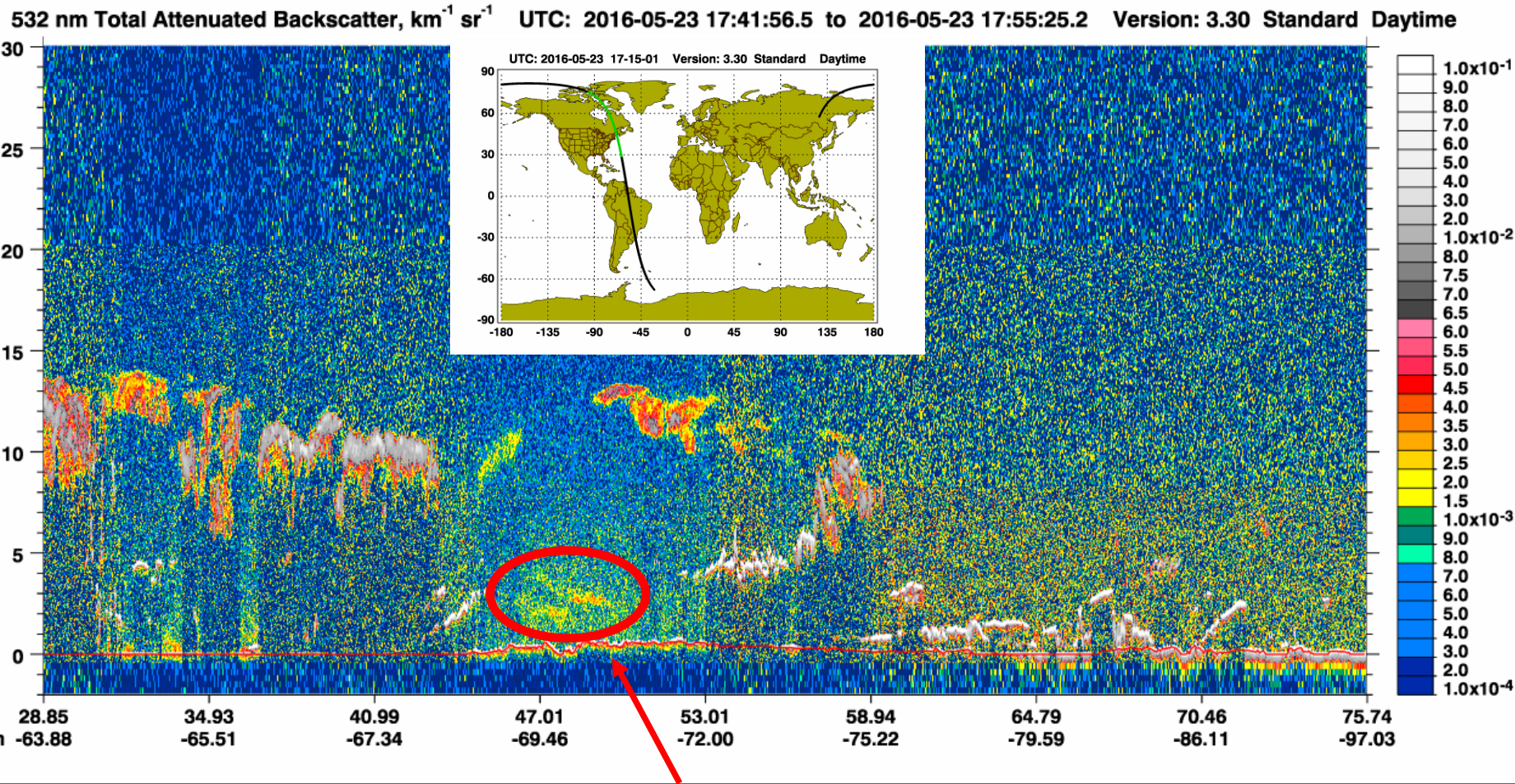
Quebec, Canada

Connecticut Department of Energy and Environmental Protection

Calipso LIDAR 5/24/16
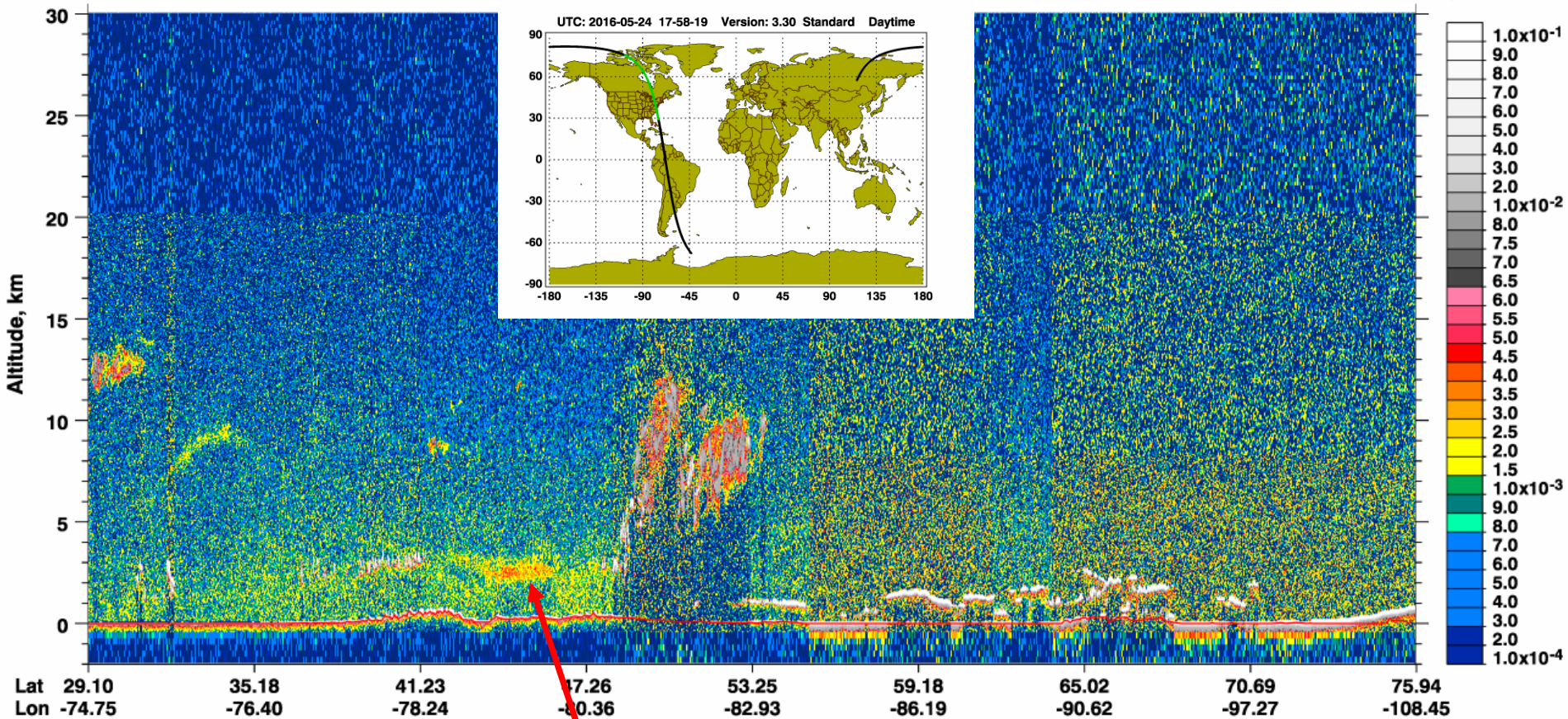
Ontario, Canada

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Back Trajectory Animation

168 hour Back Trajectories
Ending Height = 800m
Westport CT Monitor

Numerous Canadian Wildfires around Fort McMurray, Alberta on May 18, 2016

May 25, 2016 15z

Google earth

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Image IBCAO
© 2016 Google
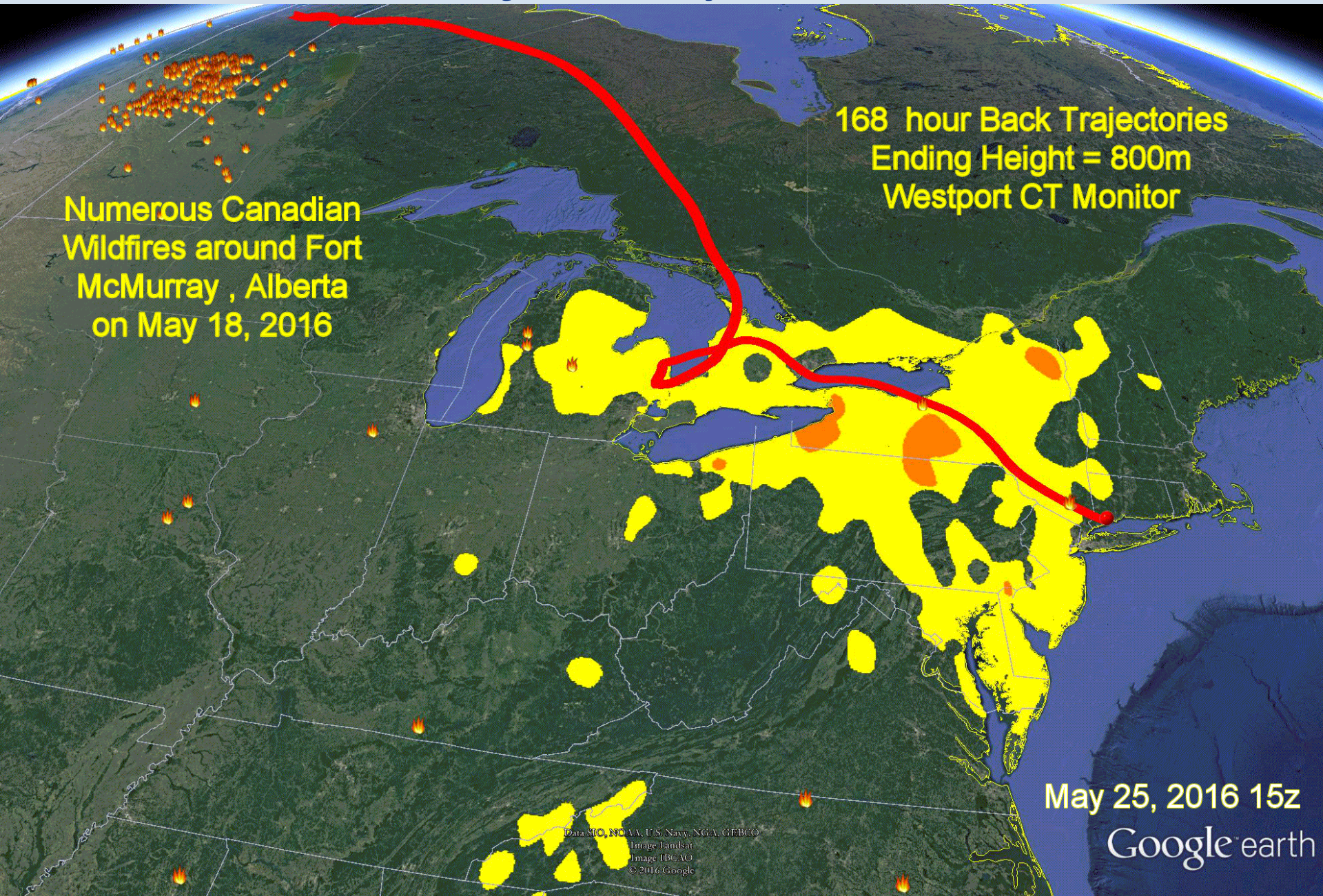
May 24-25, 2016 Surface Map and Winds
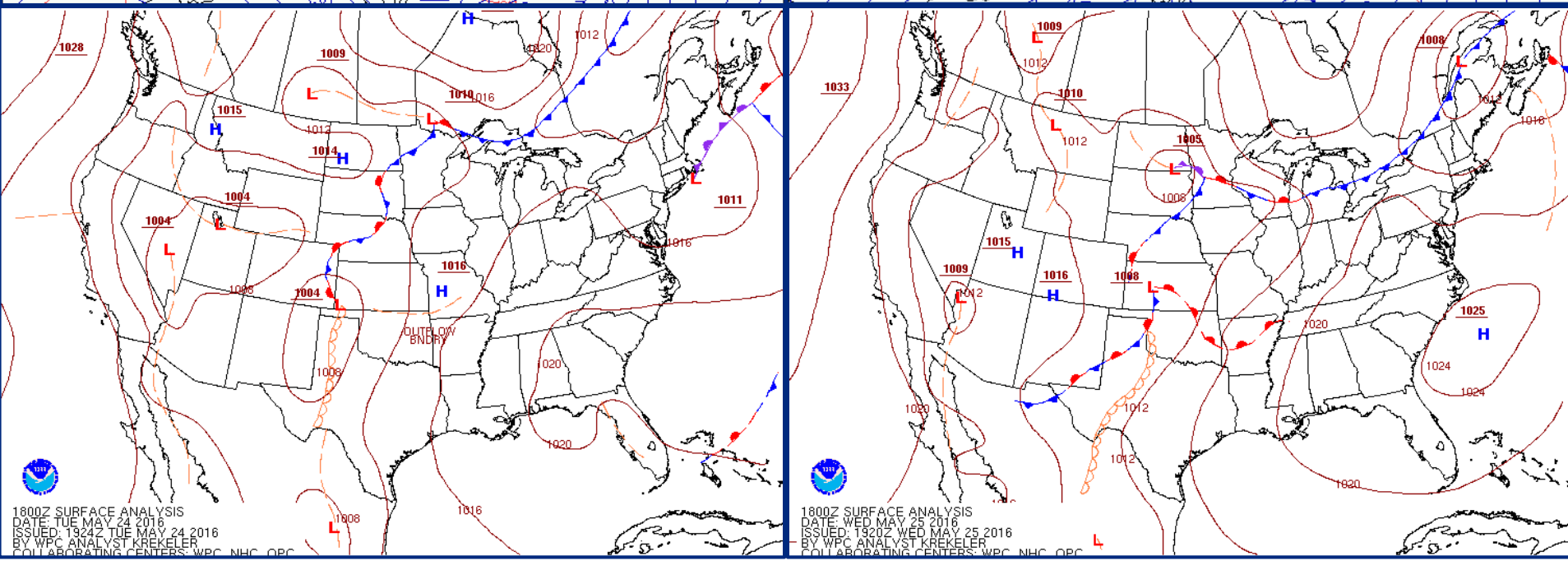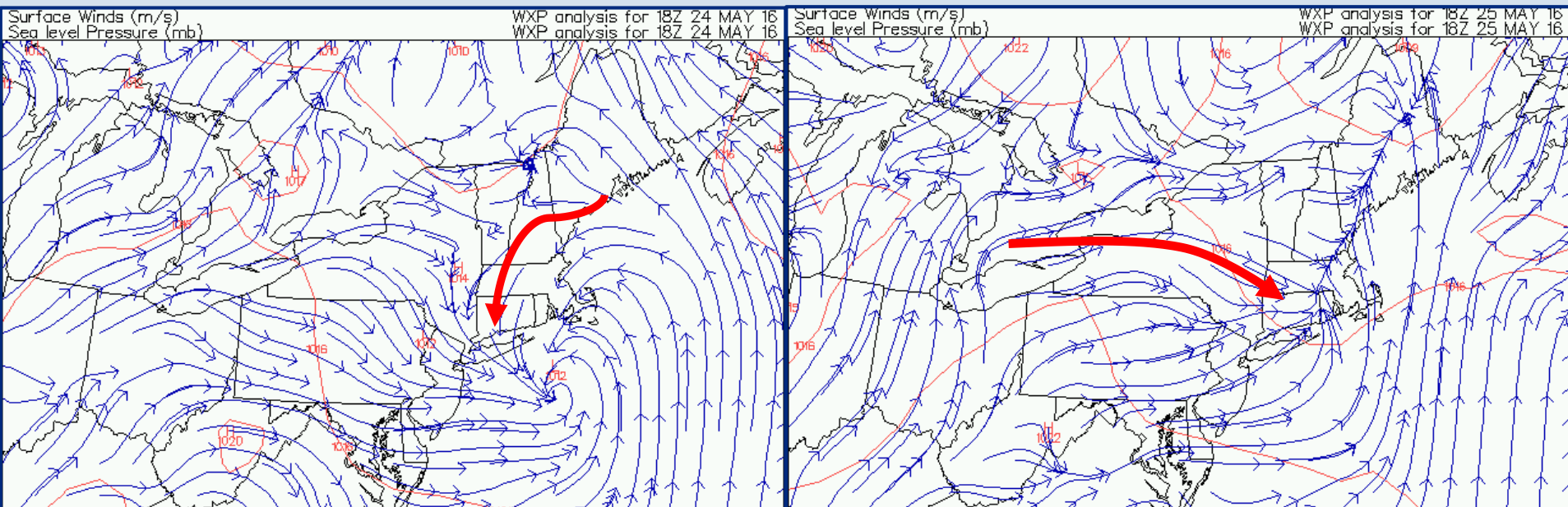
- This was the beginning of a 'smoke enhanced' multi-day ozone event for Connecticut, which lasted 5 days
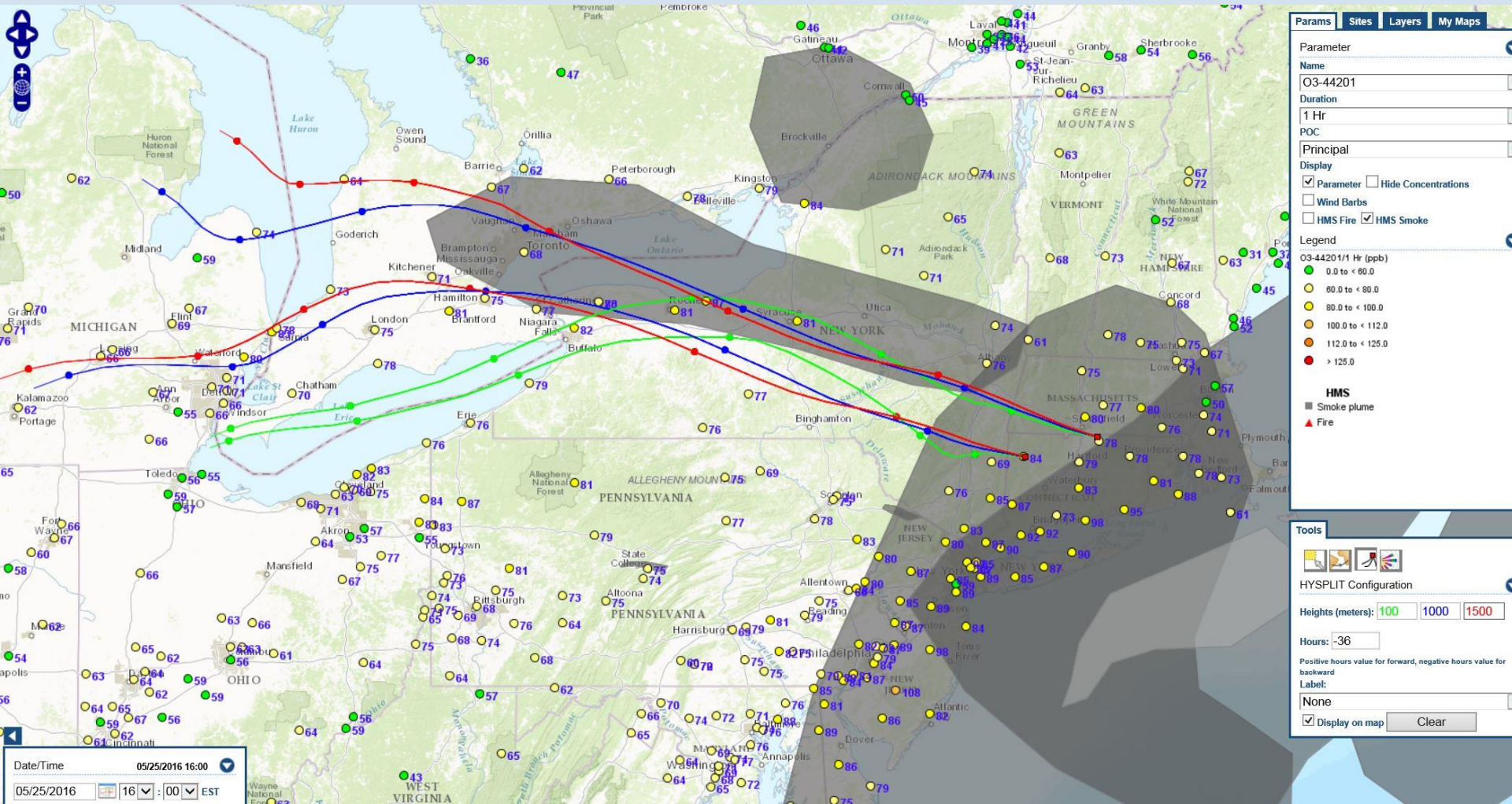
Hysplit Back Trajectories

- Hysplit offers several meteorological models to use for trajectory analysis;

- I have illustrated the differences between the NAM(12km); NAMs-hybrid and the NARR (reanalysis);

- All three models shows similar back trajectories on those days.

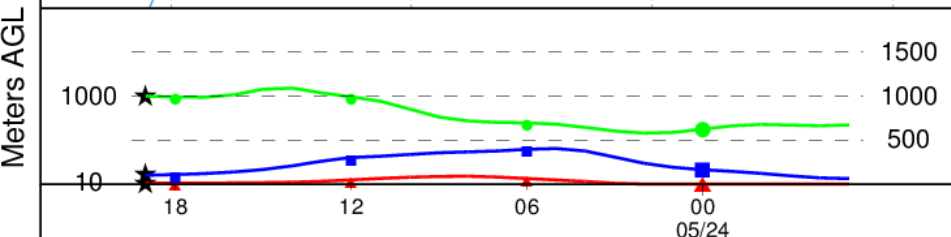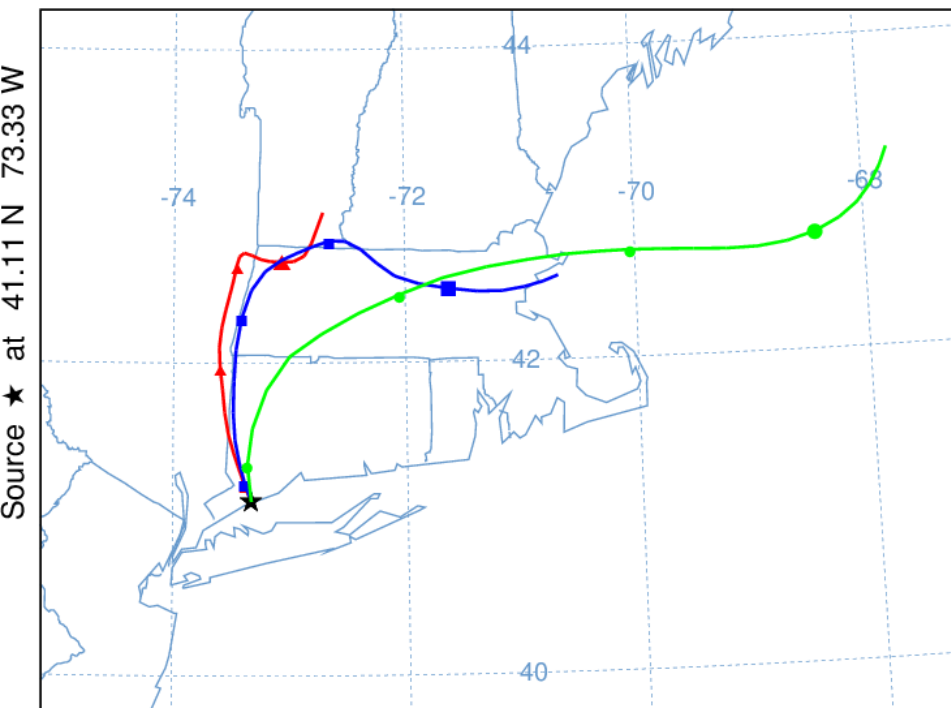Connecticut Department of Energy and Environmental Protection

May 24 -25 Back Trajectories (NAM)

NOAA HYSPLIT MODEL
Backward trajectories ending at 1900 UTC 24 May 16
NAM Meteorological Data
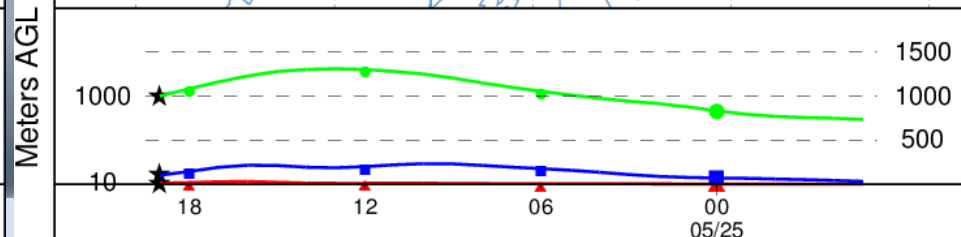
Source ★ at 41.11 N 73.33 W

Meters AGL
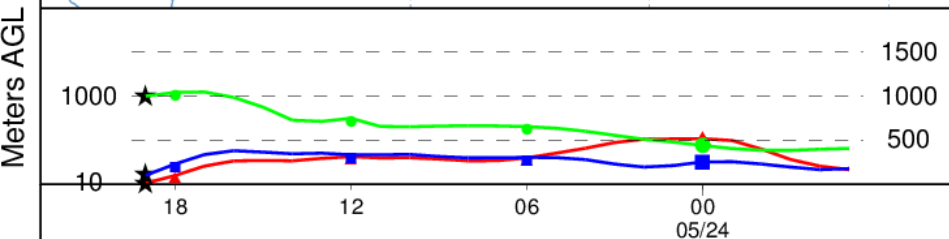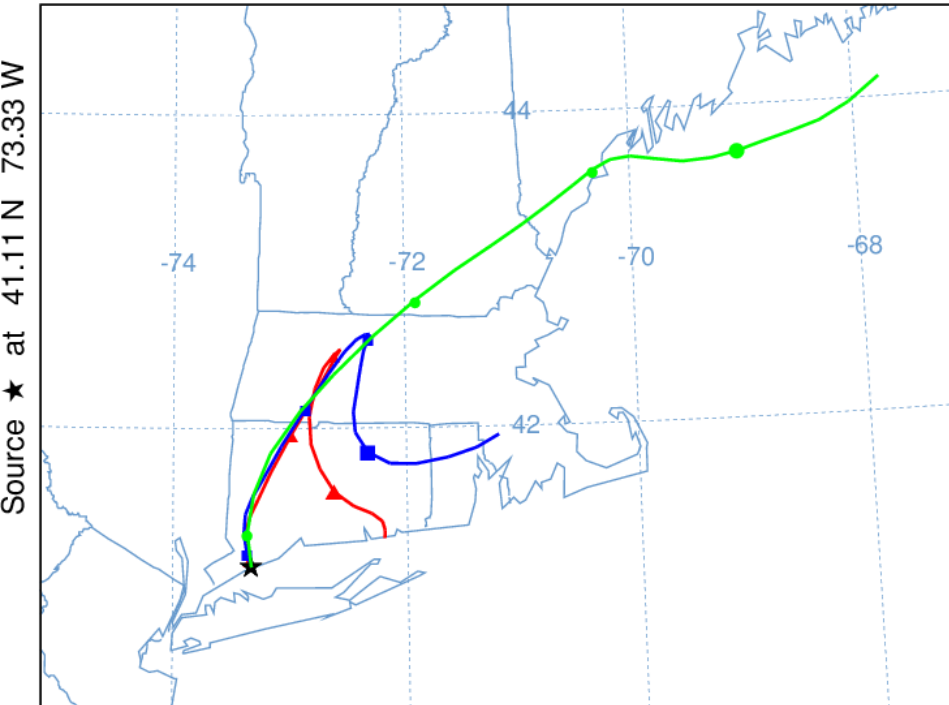
Job ID: 141961   Job Start: Tue Oct 25 19:54:33 UTC 2016
Source 1 lat.: 41.112800 lon.: -73.332400 hgts: 10, 100, 1000 m AGL

Trajectory Direction: Backward   Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 24 May 2016 - NAM12
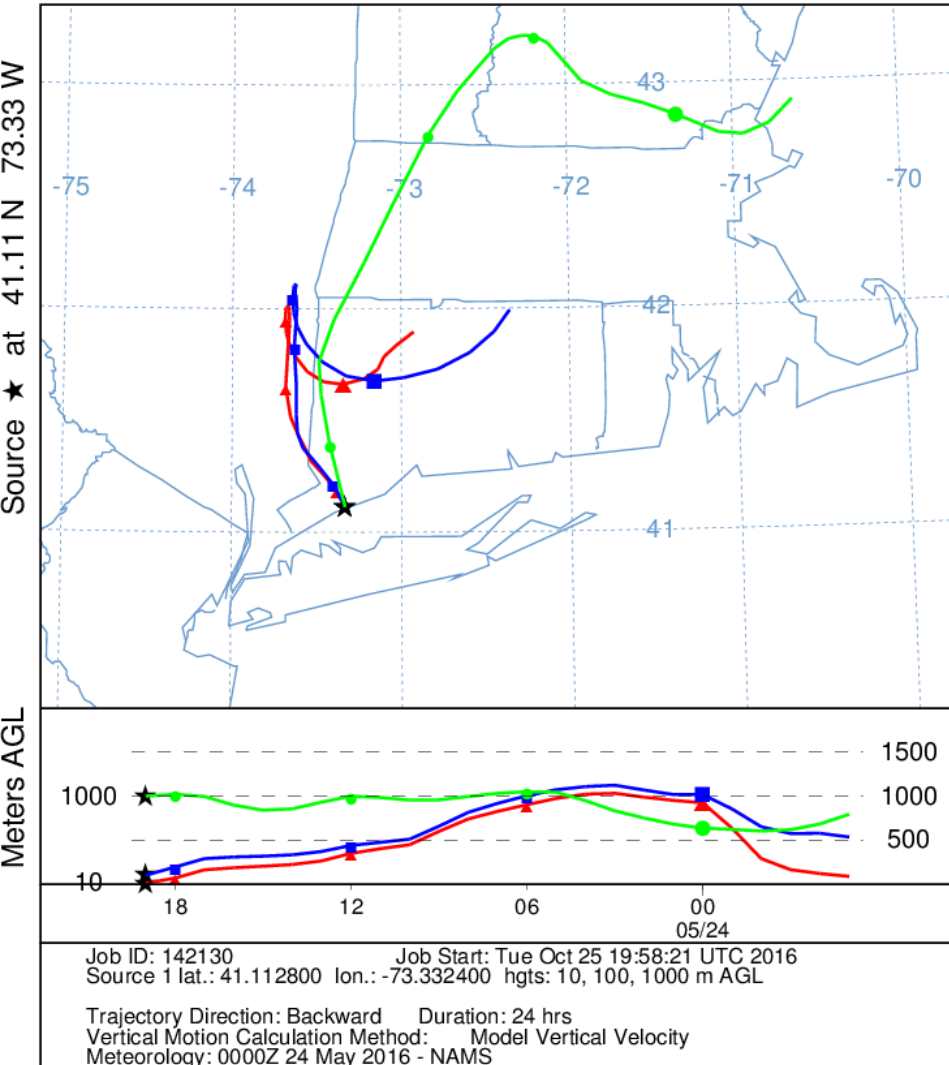
NOAA HYSPLIT MODEL
Backward trajectories ending at 1900 UTC 25 May 16
NAM Meteorological Data
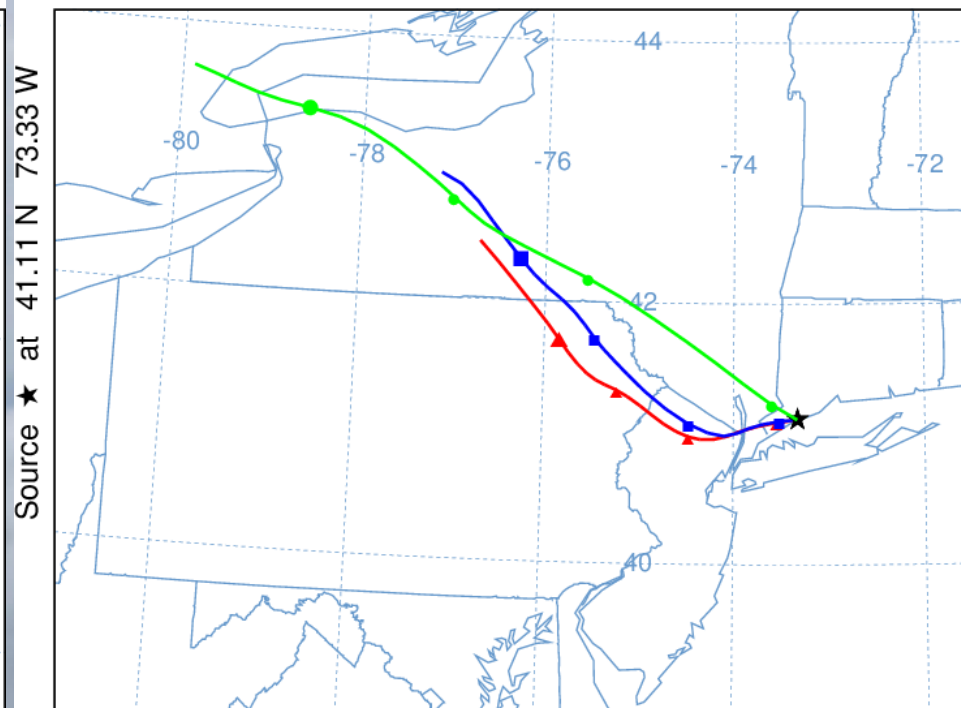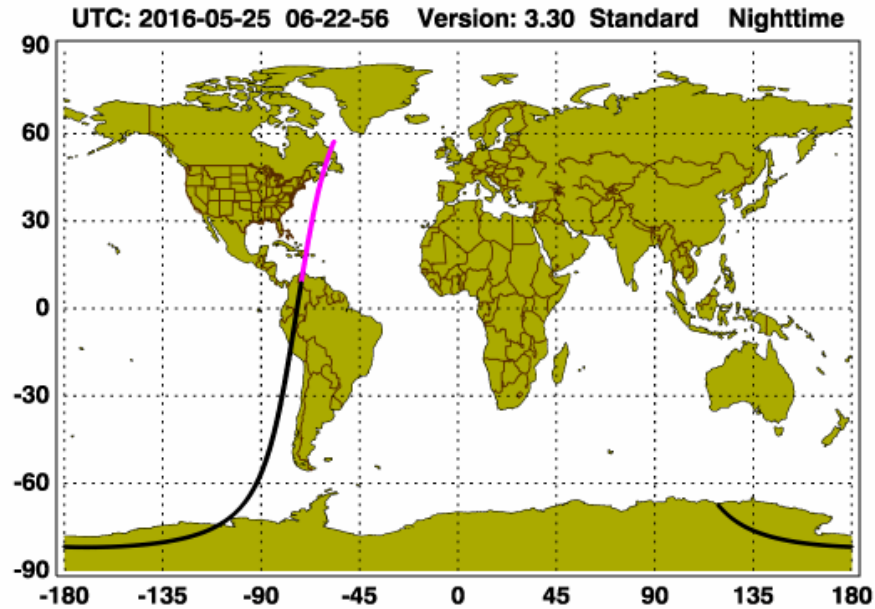
Source ★ at 41.11 N 73.33 W

Meters AGL

Job ID: 141905   Job Start: Tue Oct 25 19:51:33 UTC 2016
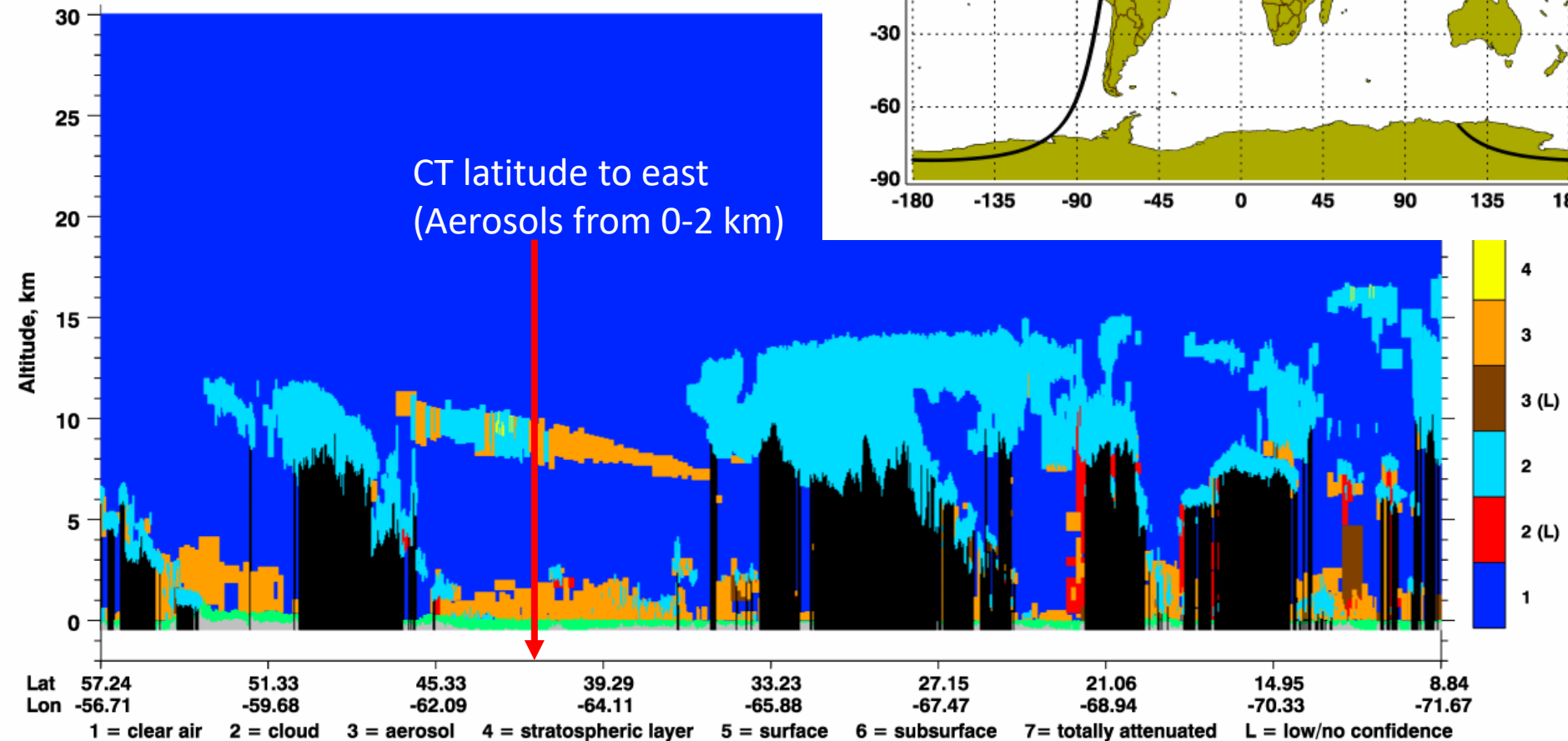Source 1 lat.: 41.112800 lon.: -73.332400 hgts: 10, 100, 1000 m AGL

Trajectory Direction: Backward   Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 25 May 2016 - NAM12

May 24 -25 Back Trajectories (NAMs)

May 24 -25 Back Trajectories (NARR)

Calipso Aerosol Cross Section May 25th

UTC: 2016-05-25 06-22-56   Version: 3.30 Standard   Nighttime

Vertical Feature Mask   UTC: 2016-05-25   06:22:51.6 to 2016-

CT latitude to east
(Aerosols from 0-2 km)

Altitude, km

| Lat | 57.24 | 51.33 | 45.33 | 39.29 | 33.23 | 27.15 | 21.06 | 14.95 | 8.84 |
| Lon | -56.71 | -59.68 | -62.09 | -64.11 | -65.88 | -67.47 | -68.94 | -70.33 | -71.67 |

1 = clear air   2 = cloud   3 = aerosol   4 = stratospheric layer   5 = surface   6 = subsurface   7= totally attenuated   L = low/no confidence

Max 8-hour Ozone May-June, 2009-2016 Animation
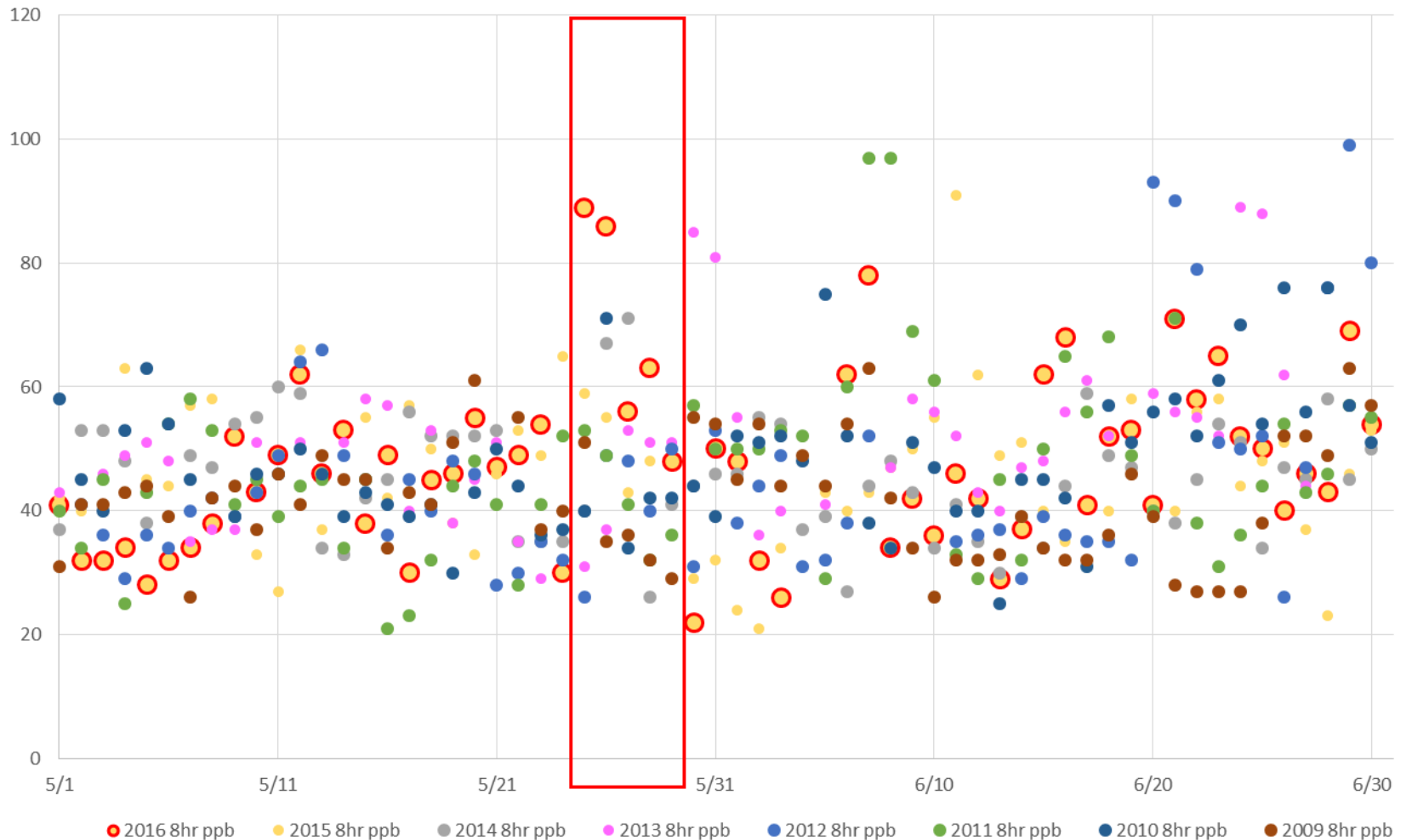
Surface Wind Rose Cornwall May-June 2016

- Hourly wind directions vs. ozone concentrations were plotted for the years 2013,2015 and 2016;
- May-June hours for each year were used to represent early season ozone patterns;
- 2016 exhibits the most elevated ozone of any year from the northwest quandrant;
- 49/56 of the 2016 exceedance hours occurred during the May 25-29 timeframe
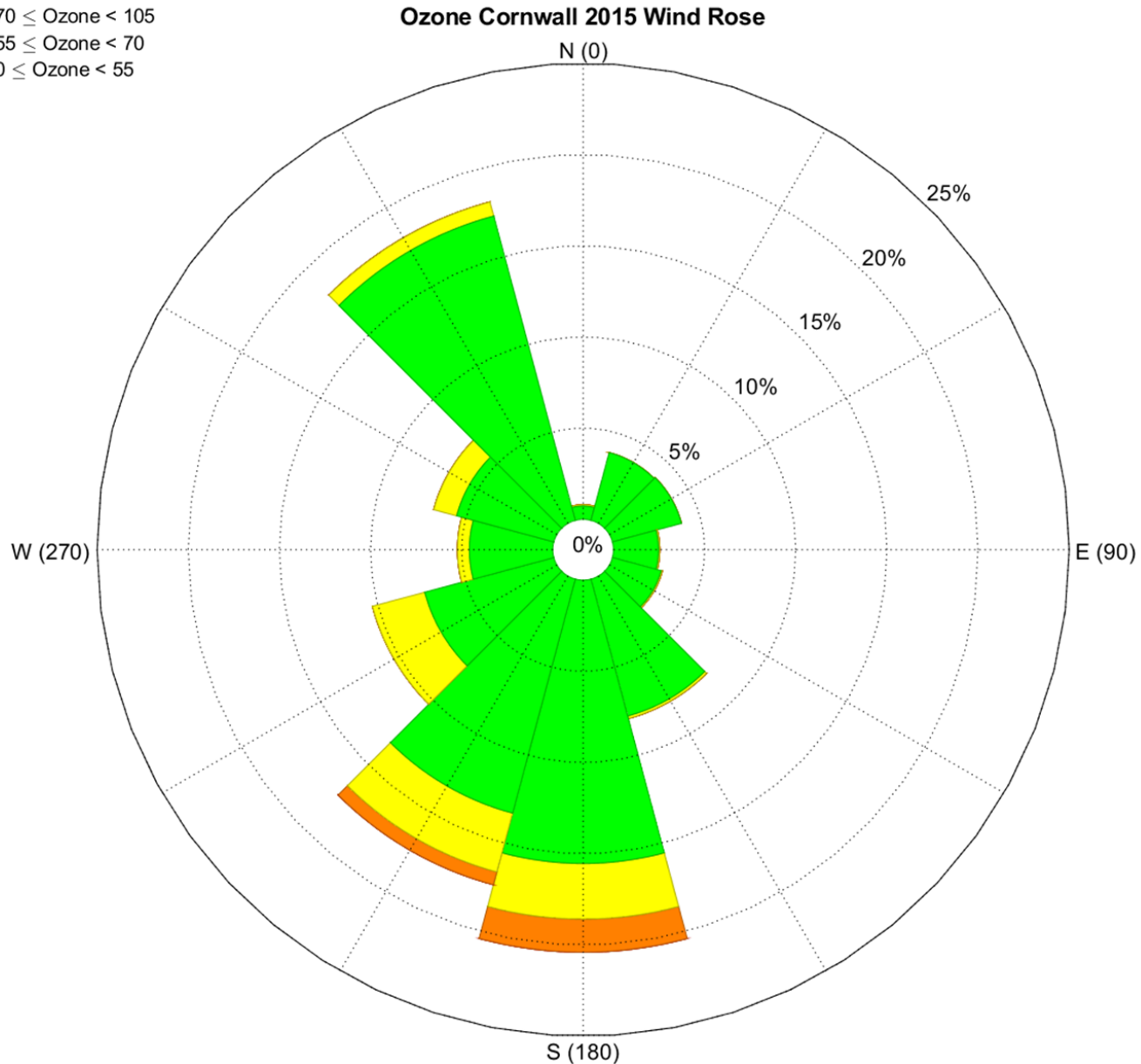
Connecticut Department of Energy and Environmental Protection
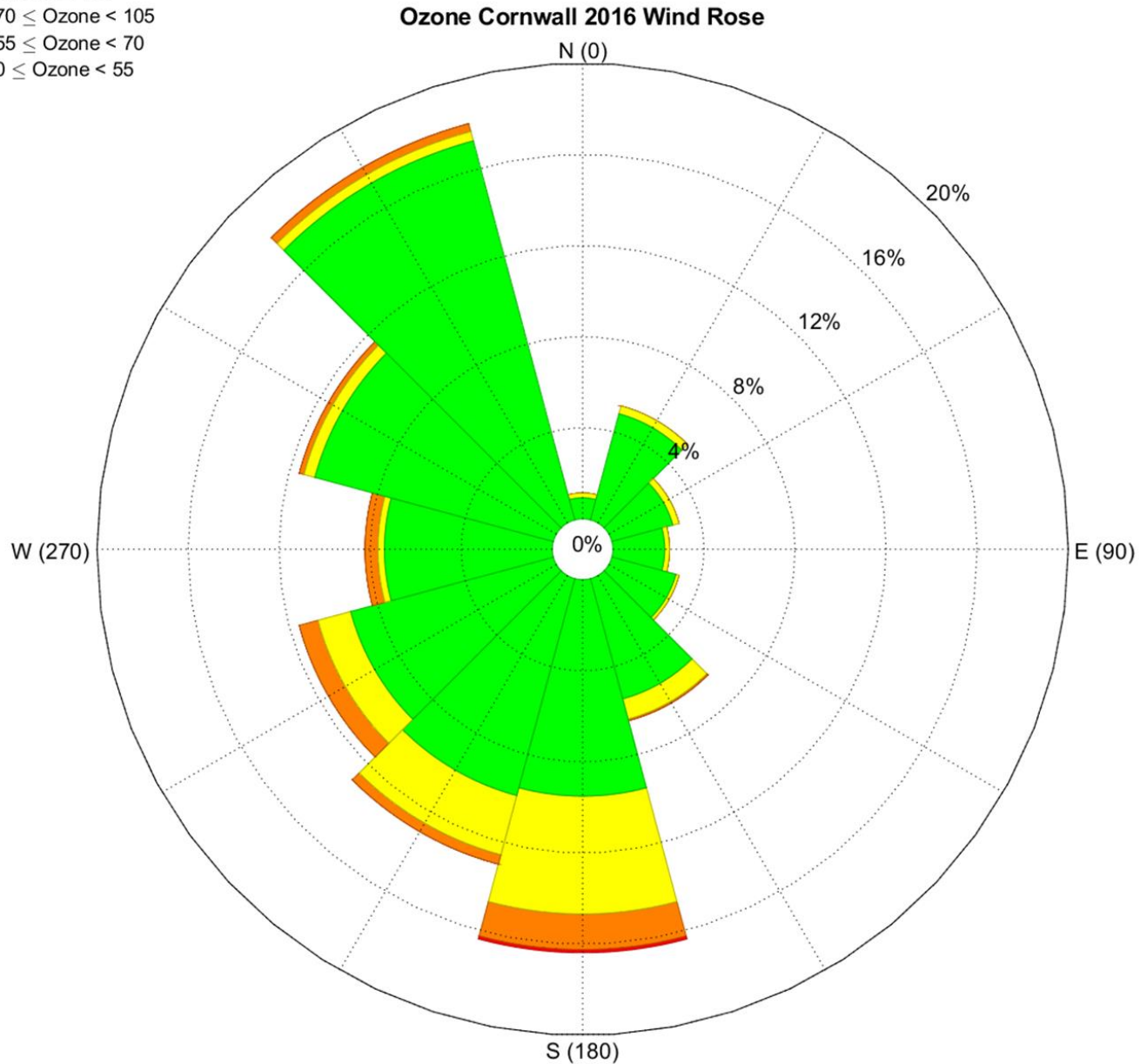
Surface Wind Rose Cornwall May-June 2016

Surface Wind Rose Cornwall May-June 2015

Surface Wind Rose Cornwall May-June 2013

Ozone Cornwall 2013 Wind Rose
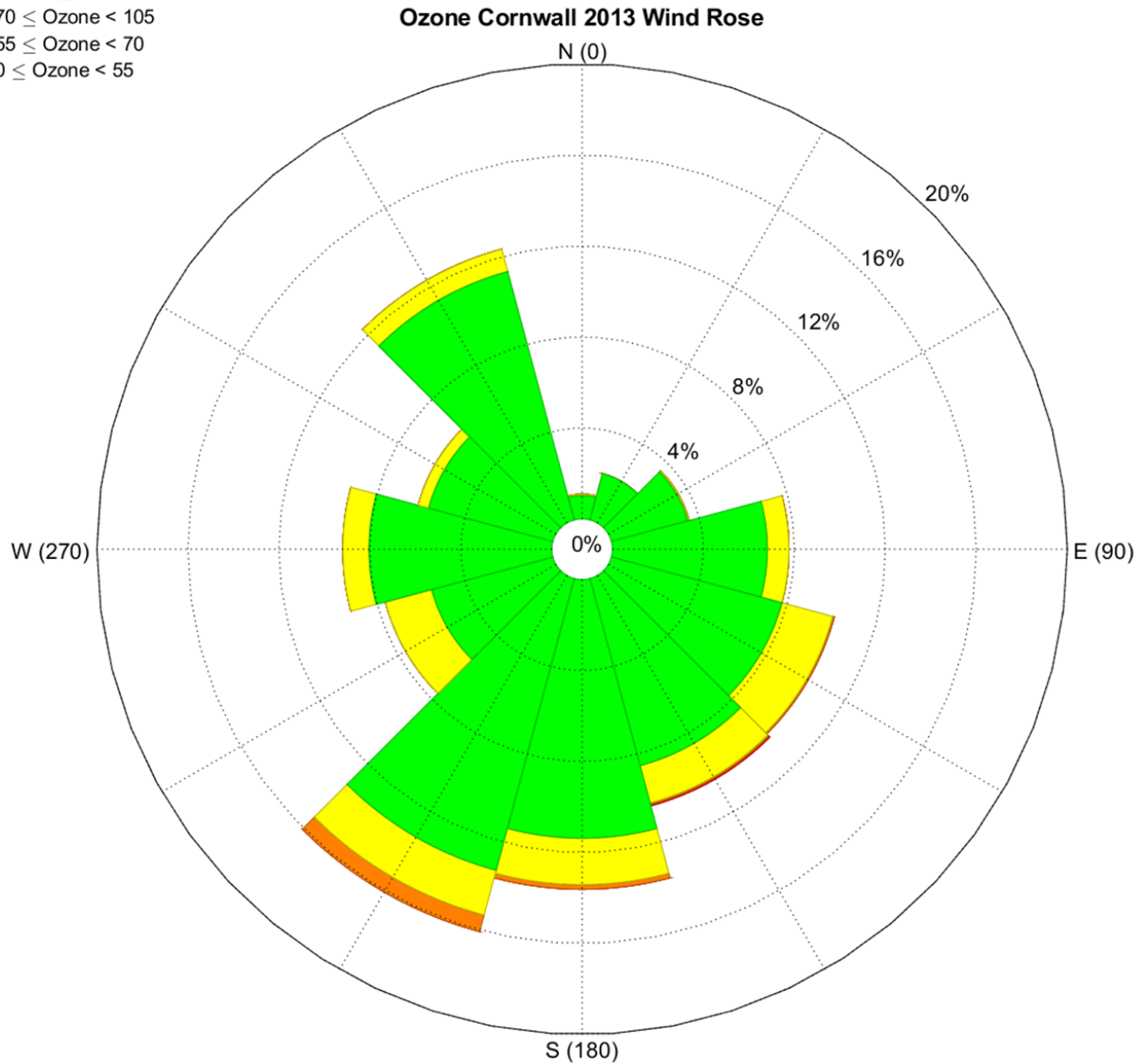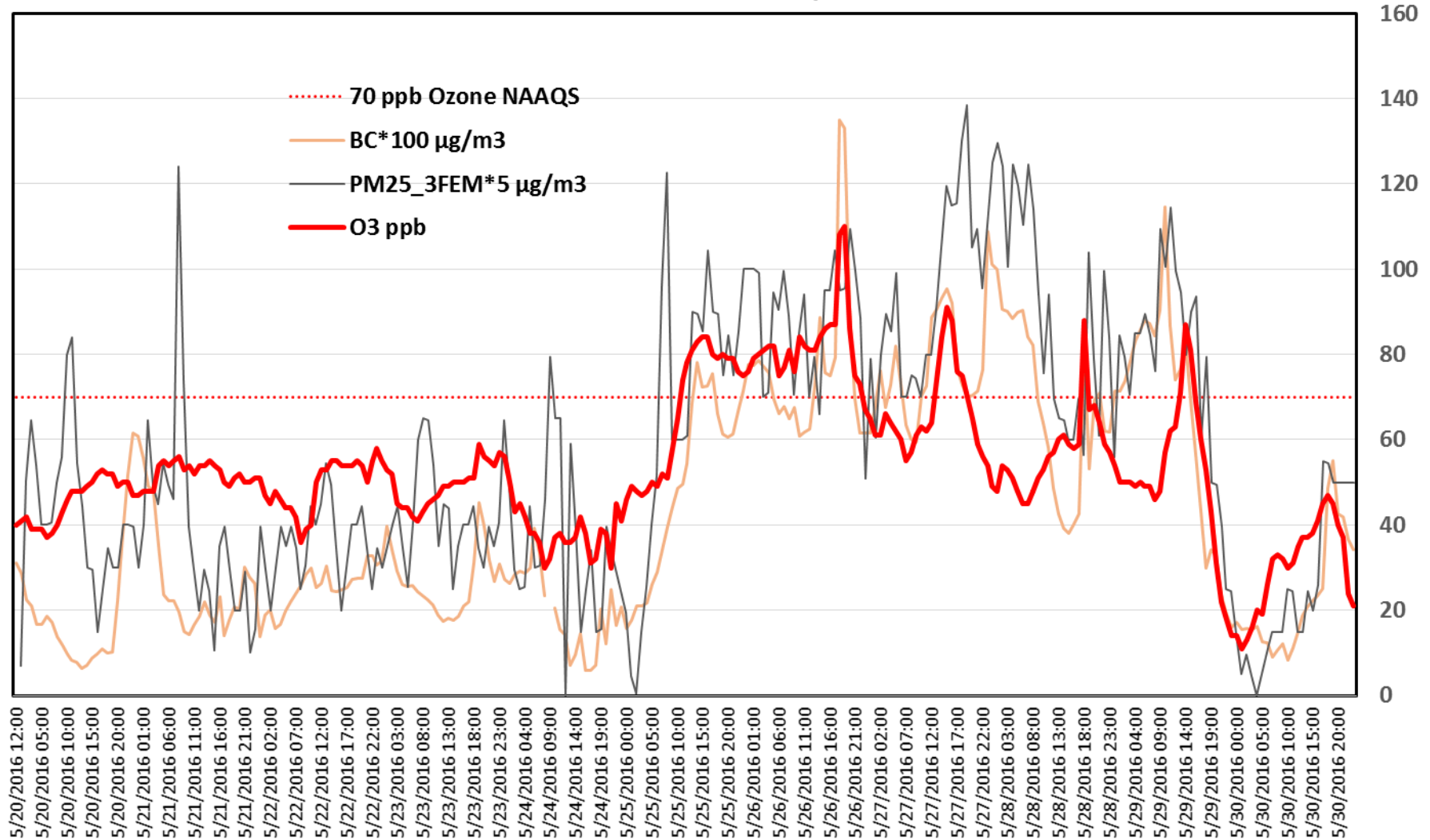
Cornwall Pollutant Charts: May 20-30, 2016

- Plots of Cornwall ozone data with Black carbon, PM2.5, 'Delta C' PM2.5 and CO show coincident increases in these species from May 25-May 29th;

- The Cornwall monitor sits at an elevation of over 1600 feet (500+m), making it the best indicator for long range, out of State pollutant transport;

- The pollutant data has been 'normalized' by multipliers for a direct comparison with the ozone concentrations.

- It was after 6:00am on May 25th that the 'event' began at the Cornwall monitor, with PM2.5 levels on the rise.

- When HYSPLIT modeled mixing height reached 600 meters at 7:00 am LST, PM2.5 levels began spiking.

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Cornwall Ozone, BC and PM2.5

- Pollutants have been scaled to match range of ozone ppbs

Cornwall Monitor May 20- 30, 2016

Legend:
- 70 ppb Ozone NAAQS
- BC*100 µg/m3
- PM25_3FEM*5 µg/m3
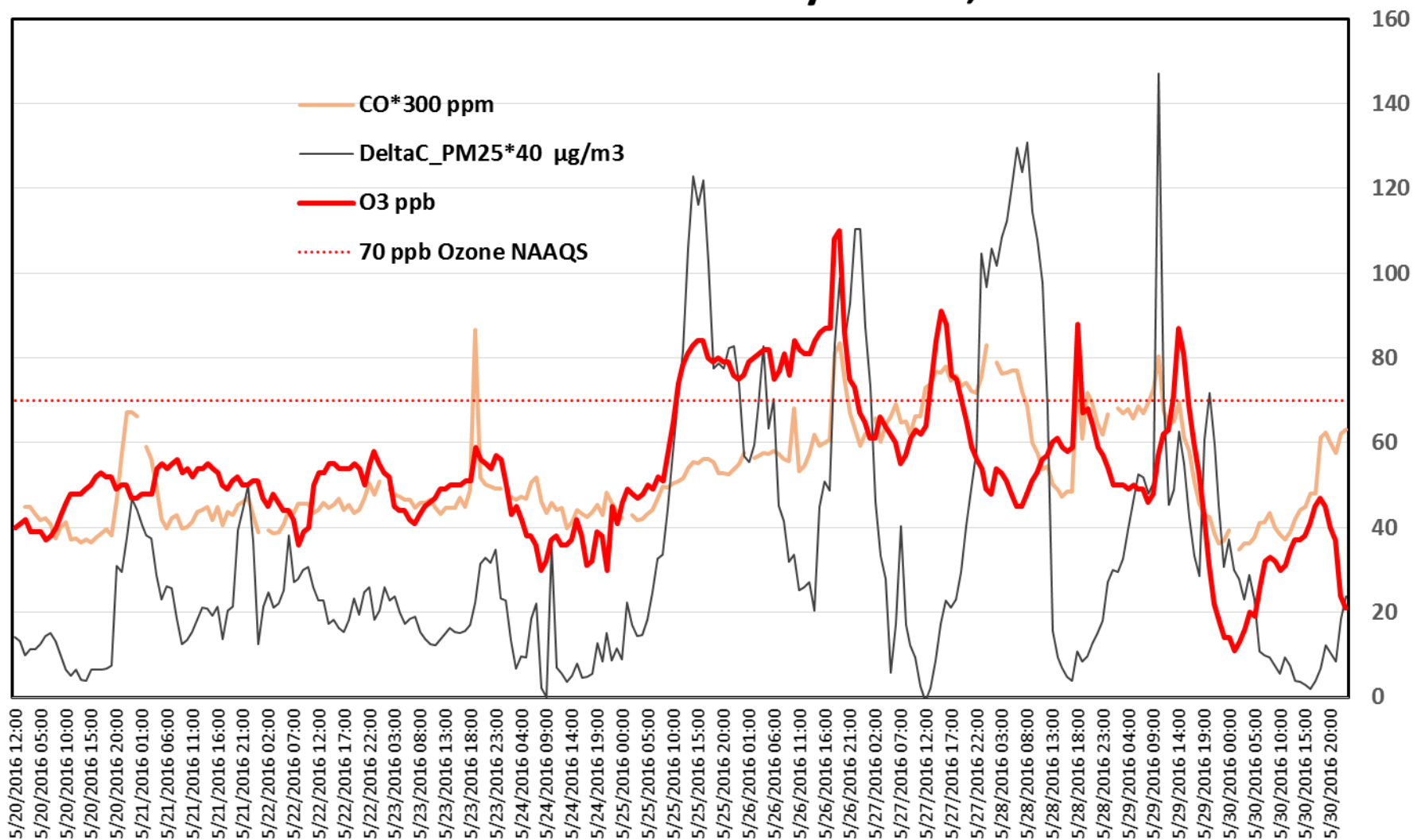- O3 ppb

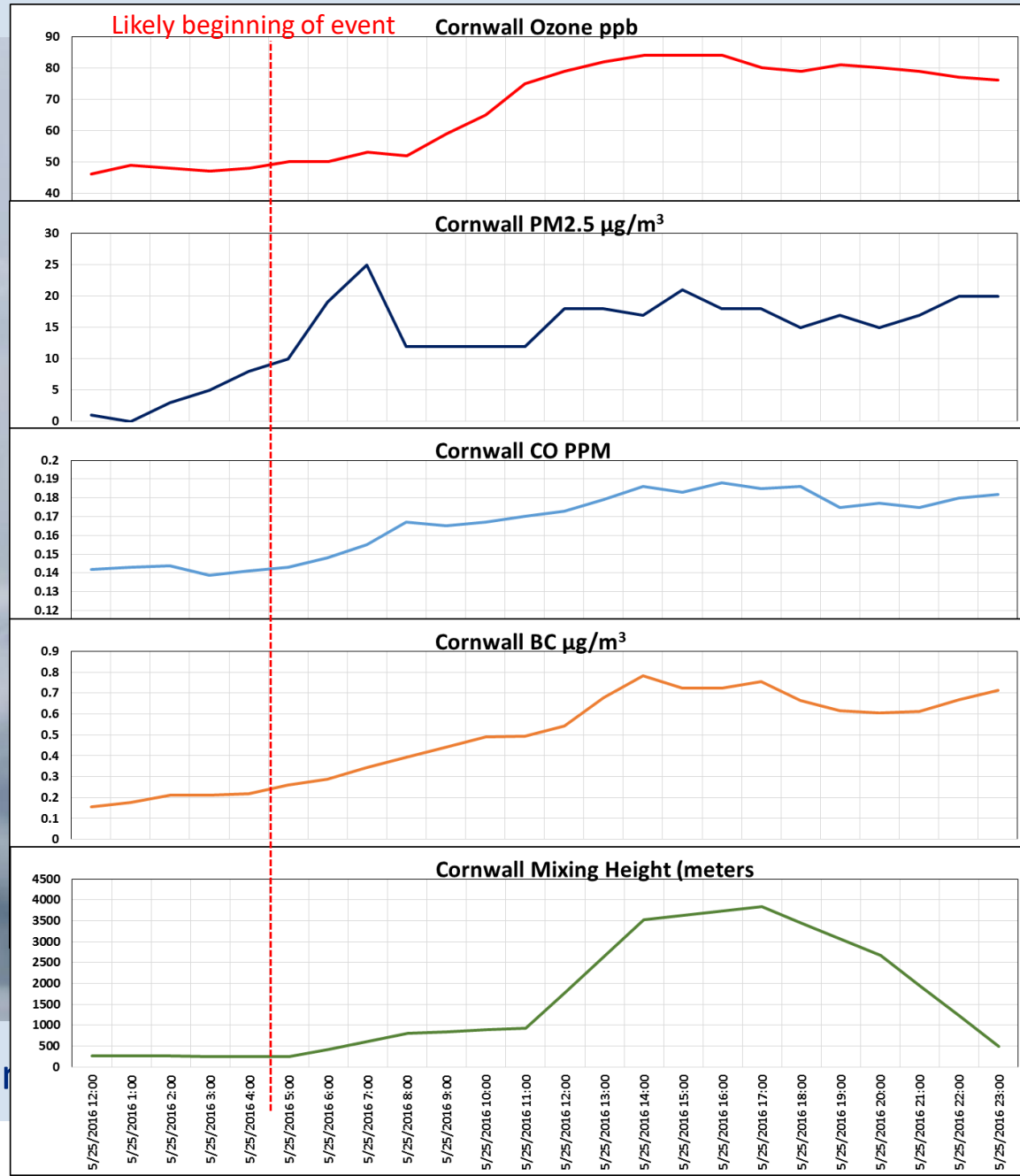# Cornwall Ozone, DeltaC and CO

- Pollutants have been scaled to match range of ozone ppbs

Cornwall Monitor May 20- 30, 2016

Stacked Charts with HYSPLIT Modeled Mixing Heights

- Note that as mixing height rises after 5:00am, so do the other parameters;

- CO and particulate matter indicate an aerosol plume likely from a wildfire.
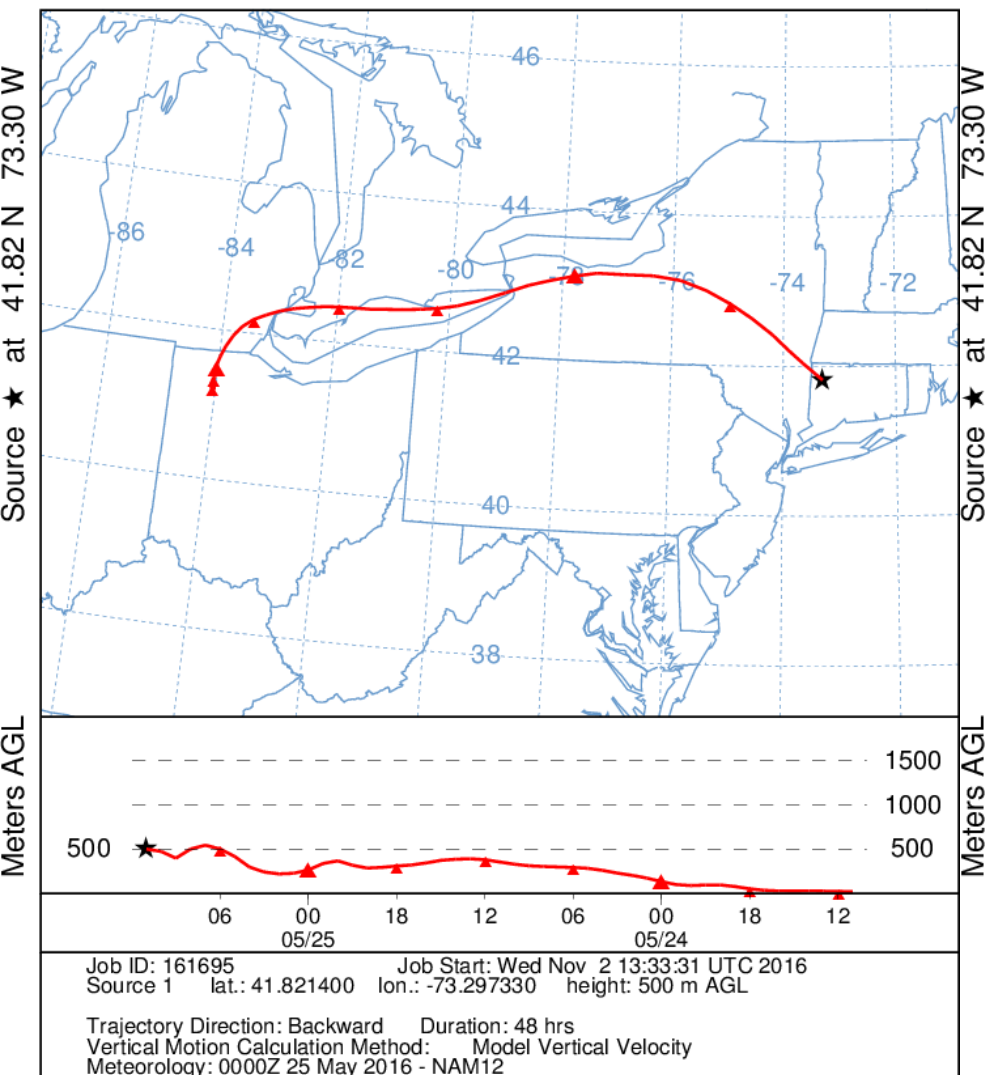
Connecticut Department

HYSPLIT 1100/1500 UTC Back Trajectories

- Back Trajectories from 1100 UTC are below 500 meters and those from 1500 UTC are above 500 meters, which shows contributions from higher levels in the atmosphere where plume was more prevalent.

NOAA HYSPLIT MODEL
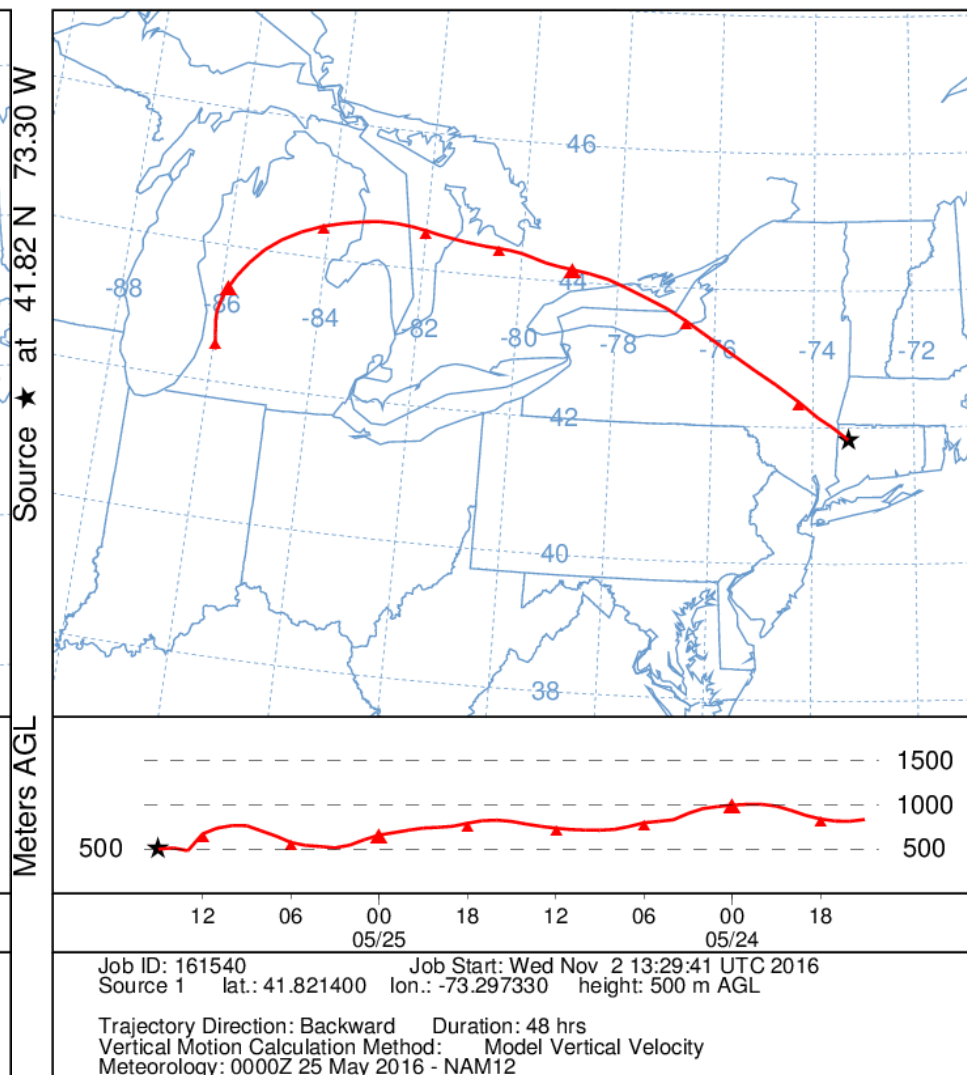Backward trajectory ending at 1100 UTC 25 May 16
NAM Meteorological Data

Job ID: 161695   Job Start: Wed Nov 2 13:33:31 UTC 2016
Source 1   lat.: 41.821400   lon.: -73.297330   height: 500 m AGL

Trajectory Direction: Backward   Duration: 48 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 25 May 2016 - NAM12

NOAA HYSPLIT MODEL
Backward trajectory ending at 1500 UTC 25 May 16
NAM Meteorological Data

Job ID: 161540   Job Start: Wed Nov 2 13:29:41 UTC 2016
Source 1   lat.: 41.821400   lon.: -73.297330   height: 500 m AGL

Trajectory Direction: Backward   Duration: 48 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
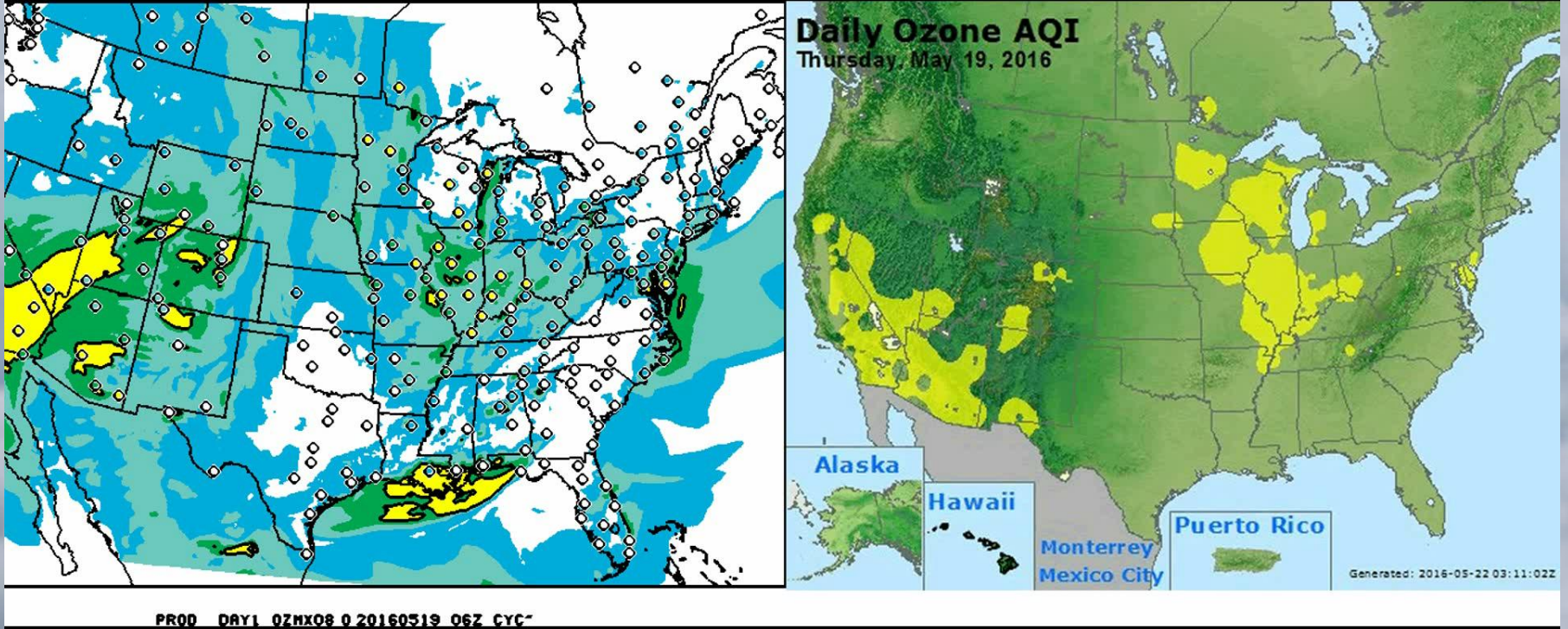Meteorology: 0000Z 25 May 2016 - NAM12

New Haven Ceilometer Back Scatter Aerosols

- Thick aerosol layer moves over New Haven after 6:00 am LST with mixing layer exceeding 3000 meters during the afternoon. This agrees well with modeled mixing height over the Cornwall monitor.
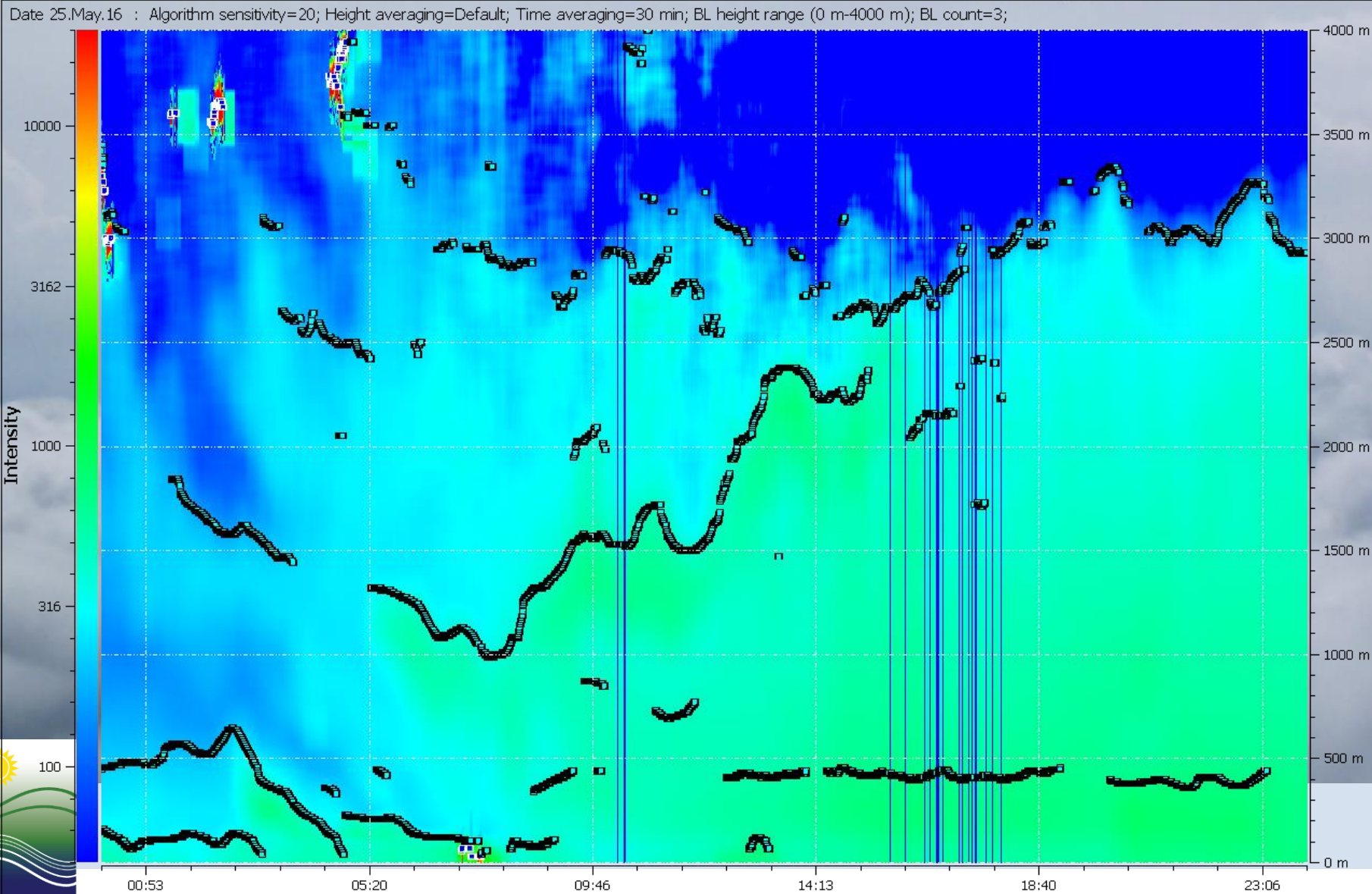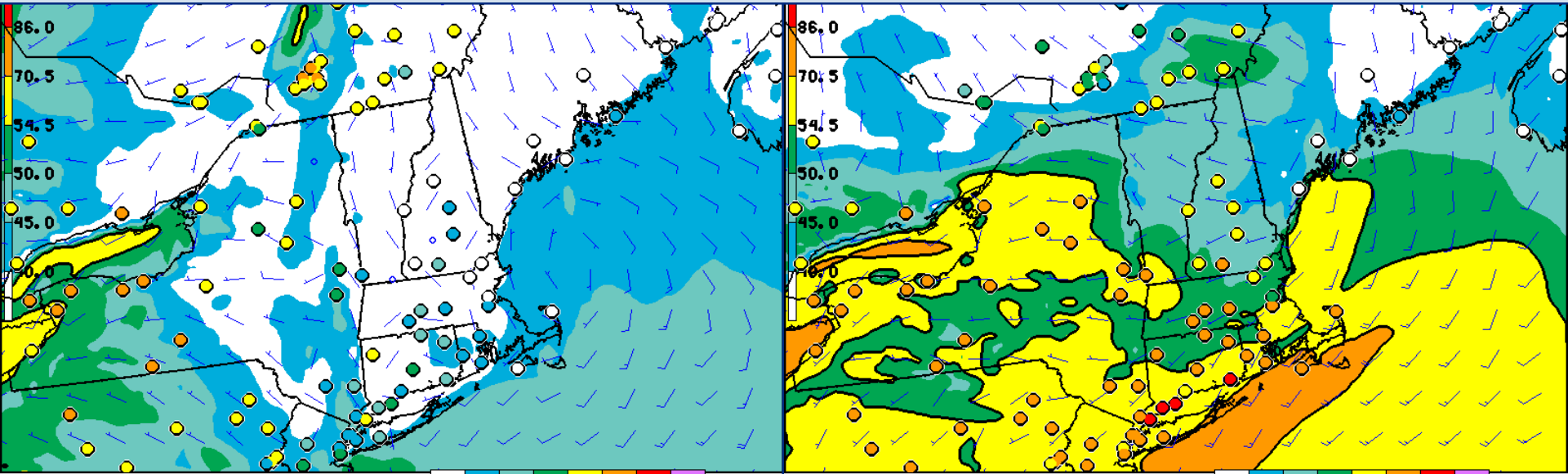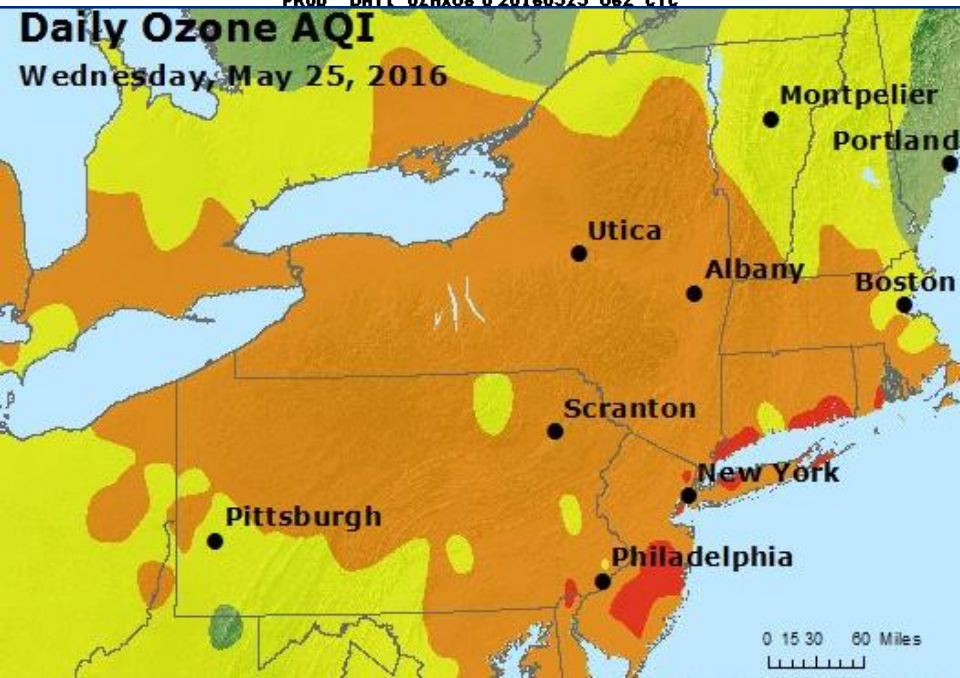
NOAA Model vs. the AQI

NE States NOAA Model/ AQI Observed

Daily Ozone AQI
Tuesday, May 24, 2016

Daily Ozone AQI
Wednesday, May 25, 2016

Conclusion

- There is no doubt that the Fort McMurray wildfire plume directly affected ozone production in the States surrounding the Great Lakes and that ozone, as well as residual pollutants from the plume, was transported to the southeast to enhance ozone production in the northeast States beginning on May 25, 2016

- All evidence points to flagging some or all of the May 25-29th period as an exceptional event.